THE FUTURE OF POLICY-ENABLED INNOVATION

TREND REPORT SPRING 2025

CDTM
CENTER FOR
DIGITAL TECHNOLOGY
AND MANAGEMENT

Bavarian State Ministry
for Digital Affairs

Kindly supported by the Bavarian State Ministry for Digital Affairs

Digitalization must yield tangible progress for the people of Bavaria — enhancing daily life, streamlining interactions with public institutions, and fostering renewed economic vitality. The Bavarian State Ministry for Digital Affairs (StMD), founded in 2018 as Germany's first dedicated ministry for digitalization, stands at the forefront of this transformation with clarity of purpose and strategic foresight.

Under the leadership of Digital Minister Dr. Fabian Mehring, the StMD serves as the architect of a modern, resilient, and future-oriented Bavaria. In close collaboration with industry, academia, and civil society, the ministry embraces its responsibility to actively shape Bavaria's digital present — and future — in the best interests of its citizens.

Visit www.stmd.bayern.de for more information.

A Project of the Center for Digital Technology and Management

The Center for Digital Technology and Management (CDTM) is a joint, interdisciplinary institution for education, research, and entrepreneurship of the Ludwig Maximilians-University (LMU) and the Technical University of Munich (TUM).

It offers the add-on study program "Technology Management" for students from various backgrounds, which provides students with tools and knowledge at the intersection of business and digital technologies.

The entire trend report was written by CDTM students under the close guidance of research assistants.

Visit www.cdtm.com for more information.

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Dr. Fabian Mehring

PREFACE OF THE PROJECT PARTNER

Policy-enabled innovations? To some, that might sound like a contradiction in terms. After all, many people still associate the state primarily with excessive regulation, sprawling bureaucracy, poor mobile coverage, slow internet, or dusty fax machines in outdated government offices. This traditional image of public administration hardly seems like an inspiring environment for innovation. In the eyes of many – often unfairly nowadays – the public sector is not exactly known as a space where people want to found companies or shape progress. Politics, according to a view that is unfortunately not entirely unfounded, has in recent years sometimes hindered innovation more than it has fostered it.

But even if that may have long been the case—and perhaps still is in some places—it doesn't have to stay that way! A modern state can in fact do a great deal to give businesses, society, and public authorities the tailwind they need to enter the AI era.

So, what might this look like in practice? That is exactly the question 25 students from Ludwig-Maximilians-Universität Munich and the Technical University of Munich explored as part of a research collaboration between the Center for Digital Technology and Management (CDTM) and my ministry. The aim: to identify pressing areas for action and develop innovative approaches to solutions. A central question was: What levers can policymakers pull, and what impulses can they set to drive the innovations the public sector urgently needs?

Over a period of six weeks, some of the brightest students in our country systematically tackled this question. They identified overarching trends and outlined possible solutions—always in close dialogue with experts from the Bavarian State Ministry for Digital Affairs and our digital agency, byte, who gladly served as sparring partners. Because we have realized that true progress can only be achieved through close cooperation between academia, industry, and politics. This is exactly the spirit in which we approached this collaboration with CDTM. While partnerships between top research institutions and industrial enterprises are now the norm, we deliberately chose to take this path with our ministry as well.

A first, then—and a great success! The project results are impressive. From around 500 initial ideas, 25 were selected in the first evaluation round. From those, the team developed five standout solutions:

- The "BayernBoost" platform to facilitate business start-ups in Bavaria,
- The "Pitch" portal enabling direct collaboration between public administration and start-ups,
- The "Workable" tool designed to strengthen employee engagement in the public sector,
- The "Baize" simulation platform to help municipalities prepare for climate change,
- And "CRAW-O", a concept to foster the circular economy for critical raw materials.

I am excited about these finalists, not only because of the diversity of their approaches and the current trends they address, but also because all five proposals are carefully thought through and strongly oriented toward practical implementation. My sincere thanks go to everyone involved who made this innovative project such a success with their dedication and enthusiasm. And here's my promise to you: your work will have real-world impact—and it will motivate my team and me to keep driving forward our contribution to more policy-enabled innovations.Together, we are shaping #TeamBayern from the brightest minds in our region—and paving the way for our state to take a leading role in the AI era!

Dr. Fabian Mehring,
Bavarian State Minister for Digital Affairs

Felix Dörpmund 
Sebastian Sartor 

PREFACE OF THE EDITORS

> **Everybody can learn from the past. Today it is important to learn from the future!**
> Herman Kahn

As one of the founding fathers of modern scenario planning, Herman Kahn captured a truth that feels more relevant than ever. In times of rapid technological and societal change, it's no longer enough to react to the future - we must actively explore it. This is especially true for governments and policy-makers: not only must they create the conditions for innovation to thrive in society - among startups, industry, and academia - but they must also rethink and reinvent how government works. Innovation in policy-making and innovation through policies go hand in hand.

At CDTM, our mission is to connect, educate, and empower the innovators of tomorrow. We equip our students with the tools and mindset they need to become responsible leaders who actively craft their future environments - rather than merely respond to change.

This Trend Report is the outcome of the Trend Seminar, a cornerstone of our interdisciplinary Technology Management curriculum. In this course, 25 highly motivated students from diverse backgrounds - from Business and Psychology to Medicine, Computer Science, and Engineering - come together to explore a pressing topic of our time. Over seven intensive weeks during their semester break, students dive deep into research, develop forward-looking scenarios, and translate their insights into tangible ideas and business concepts. Working in interdisciplinary teams, they combine domain expertise with fresh perspectives and an entrepreneurial mindset.

We would like to extend our sincere gratitude to everyone who made this Trend Report possible:

First, our heartfelt thanks go to the Bavarian Ministry for Digital Affairs for their generous support of this seminar. In particular, we would like to thank Dr. Fabian Mehring, along with Theresa Näßl, Michael Edenhofer, Sabine Donauer, and Antonia Zierer for their collaboration, guidance, and thoughtful feedback throughout the project. We hope our insights contribute meaningfully to your mission of fostering policy-enabled innovation.

In addition, we very much thank all our lecturers, who shared their knowledge and largely contributed to this project's success:

Aaron Defort (BCG, CDTM)
Aliosha Milsztein (CDTM)
Andreas Klinger (EU Inc)
Andreas Mix (KION Group)
Benjamin Frisch (CERN)
Dr. Johannes Sedlmeir (University of Luxembourg)
Dr. Michael Fröhlich (Ark Climate, CDTM)
Dr. Pasha Shabalin (Marvel Fusion, CDTM)
Dr. Ricardo Schäfer (Zone II Ventures)
Florian Kristof (CDTM)
Isabel Tscherniak (CDTM)
Jan Damm (Dataleap, CDTM)
Jan Krüger (Co-Power Energy)
Jeremiah Hendren (Hendren Writing)
Johanna Ballesteros (GovTech Campus)
Kilian Seitz (SPRIN-D)
Lisa Oberaigner (Emidat, CDTM)
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Lucas Didier (Hula Earth)
Manuel Braun (Systemiq, CDTM)
Martin Wessel (CDTM)
Matthias Möller (CDTM, Buildery)
Nina Odefey (Lakestar)
Oliver Schoppe (UVC Partners)
Peter van Woerkum (Regulate)
Prof. Dietmar Harhoff (Max Planck Society, CDTM)
Silvia Rettinger (University of Vienna)
Steffen Schülzchen (Entrix, CDTM)
Svetlana Tokareva (UVC, CDTM)
Viola Nuener (CDTM)
Zhenya Loginov (Accel)

Last but not least, we thank the CDTM Spring 2025 class, whose energy, curiosity, and dedication made this project a true pleasure to supervise. A special shoutout goes to the editing, layout, and quality assurance teams, whose hard work brought this report to life.

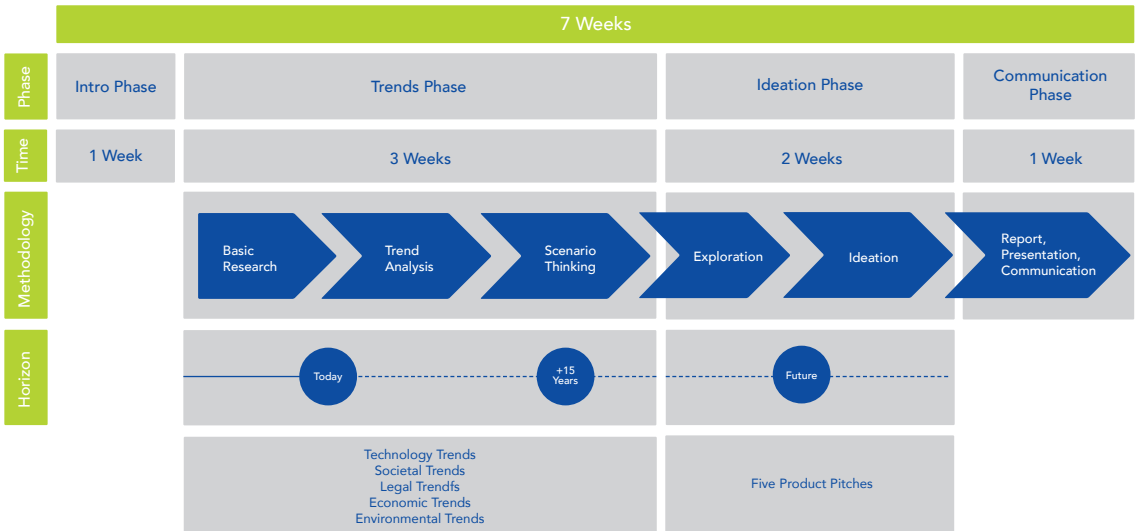
Felix Dörpmund and Sebastian Sartor

Center for Digital Technology and Management

METHODOLOGY

The objective of the Trend Seminar is to provide a methodological approach for diving into a specific subject or industry sector and contemplating its future trajectory. The seminar guides its participants through three phases of trend research: trend, exploration, and ideation. Following this approach, the seminar first analyzes current trends and developments using in-depth desk research, site visits, and interviews with leading experts to establish a shared industry understanding. Next, participants identify areas within the sector where problems and opportunities will likely arise. In the final seminar phase, the students generate future-proof business ideas for products and services, addressing the identified problems and opportunities.

Up to twenty-six students, supervised by two doctoral candidates, pursue the Trend Seminar for seven weeks full-time during their semester break. The sector and framing for the seminar is provided by project partners from within the industry, who share their expertise and feedback, acting as sparring partners to the participants. In each phase, interdisciplinary subteams are formed with students from business, technology, and other disciplines. This interdisciplinarity allows for novel ways of thinking and the development of non-obvious ideas as well as leveraging the students' professional and personal growth throughout the course.



During the introduction week, the participants are prepared for the intense trend research ahead. First and foremost, the students are introduced to the specific industry the seminar is diving into. Project partners and industry experts present past and current industry developments from their individual stakeholder perspectives, engaging in open discussions with the students. Additionally, interactive sessions teach trend research methodologies and refine the participants' communication and teamwork skills.

Following the introduction, the **trends phase** of the seminar covers desk research, expert interviews, and expert lectures, enabling the participants to dive deep into the topic at hand. During the expert interviews, students are empowered to pose specific questions to challenge their initial assumptions on how the industry will develop. Beyond that, site visits at the project partners' facilities complement the students' body of research and allow for further verification of their hypotheses. The derived trends are extrapolated 15 years into the future, providing a long-term perspective.

The first half of the **ideation phase** is about **exploring**. Future opportunities and problems are clustered into specific spaces based on the research done in the preceding phase. The students are reshuffled into new teams and explore these spaces by looking into existing start-ups and projects. Through interviews and discussions with industry experts, the teams validate their hypotheses to identify unmet needs and existing gaps in the industry landscape.

During the second half of the **ideation phase**, students brainstorm **business solutions** addressing the previously identified gaps. To facilitate the ideation process, the students are introduced to structured and unstructured ideation methods. This allows them to generate many ideas before consolidating them and building comprehensive business models. Finally, the research results and the business ideas are pitched to the project partners, industry stakeholders, and the general public.

LIST OF ABBREVIATIONS

3GPP
3rd Generation Partnership Project

ABM
Agent-Based Modeling

AfD
Alternative for Germany

AI
Artificial Intelligence

AIaaS
AI-as-a-Service

API
Application Programming Interface

CBAM
Carbon Border Adjustment Mechanism

CDM
Clean Development Mechanism

CDU
Christian Democratic Union of Germany

CSU
Christian Social Union in Bavaria

CMRA
Climate Mapping for Resilience and Adaptation

CRMA
Critical Raw Materials Act

CSRD
Corporate Sustainability Reporting Directivet

DAOs
Decentralized Autonomous Organizations

DARPA
Defense Advanced Research Projects Agencye

DPP
Digital Product Passport

DTN
Data Transmission Network

EAC
Energy Attribute Certificate

eID
Electronic Identification

EPD
Environmental Product Declaration

ESG
Environmental, Social, and Governancet

ETS
Emissions Trading System

ETSI
European Telecommunications Standards Institute

EU
European Union

EUR
Euro

EV
Electric Vehicles

EX
Employee Experience

EXP
Employee Experience Platform

FCA
Financial Conduct Authority

GDP
Gross Domestic Product

GDPR
General Data Protection Regulation

GHG
Greenhouse Gas

GSMA
Groupe Spéciale Mobile Association

GW
Gigawatts

HR
Human Resources

ICT
Information and Communications Technology

IGLU
Internationale Grundschul-Lese-Untersuchung

IPCEI
Important Projects of Common European Interest

ISAC
Integrated Sensing and Communication

ISO
International Organization for Standardization

IT
Information Technology

ITU-T
International Telecommunication Union - Telecommunication Standardization Sector

JOGMEC
Japan Oil, Gas and Metals National Corporation

KfW
Kreditanstalt für Wiederaufbau (Reconstruction Credit Institute)

KPX
Korea Power Exchange

KRITIS
Critical Infrastructure Protection

KTF
Climate and Transformation Fund

LCPs
Low-Code Platforms

LLM
Large Language Model

MAAI
Multi-Agent Artificial Intelligence

MBI
Market-Based Instruments

ML
Machine Learning

MVPs
Minimum Viable Product

MWh
Megawatt-hour

NCPs
No-Code Platforms

NLP
Natural Language Processing

OECD
Organisation for Economic Co-operation and Development

PA
Precision Agriculture

PACM
Paris Agreement Crediting Mechanism

PFA
Perfluoroalkyl and Polyfluoroalkyl Substances

PISA
Programme for International Student Assessment

R&D
Research and Development

REACH
Registration, Evaluation, Authorisation, and Restriction of Chemicals

ROI
Return on Investment

SaaS
Software-as-a-Service

SDG
Sustainable Development Goal

SME
Small and Medium Enterprise

UAE
United Arab Emirates

UK
United Kingdom

US
United States

USD
United States Dollar

VC
Venture Capital

VESTAP
Vulnerability AssESsment Tool to Build Climate Change Adaptation Plan

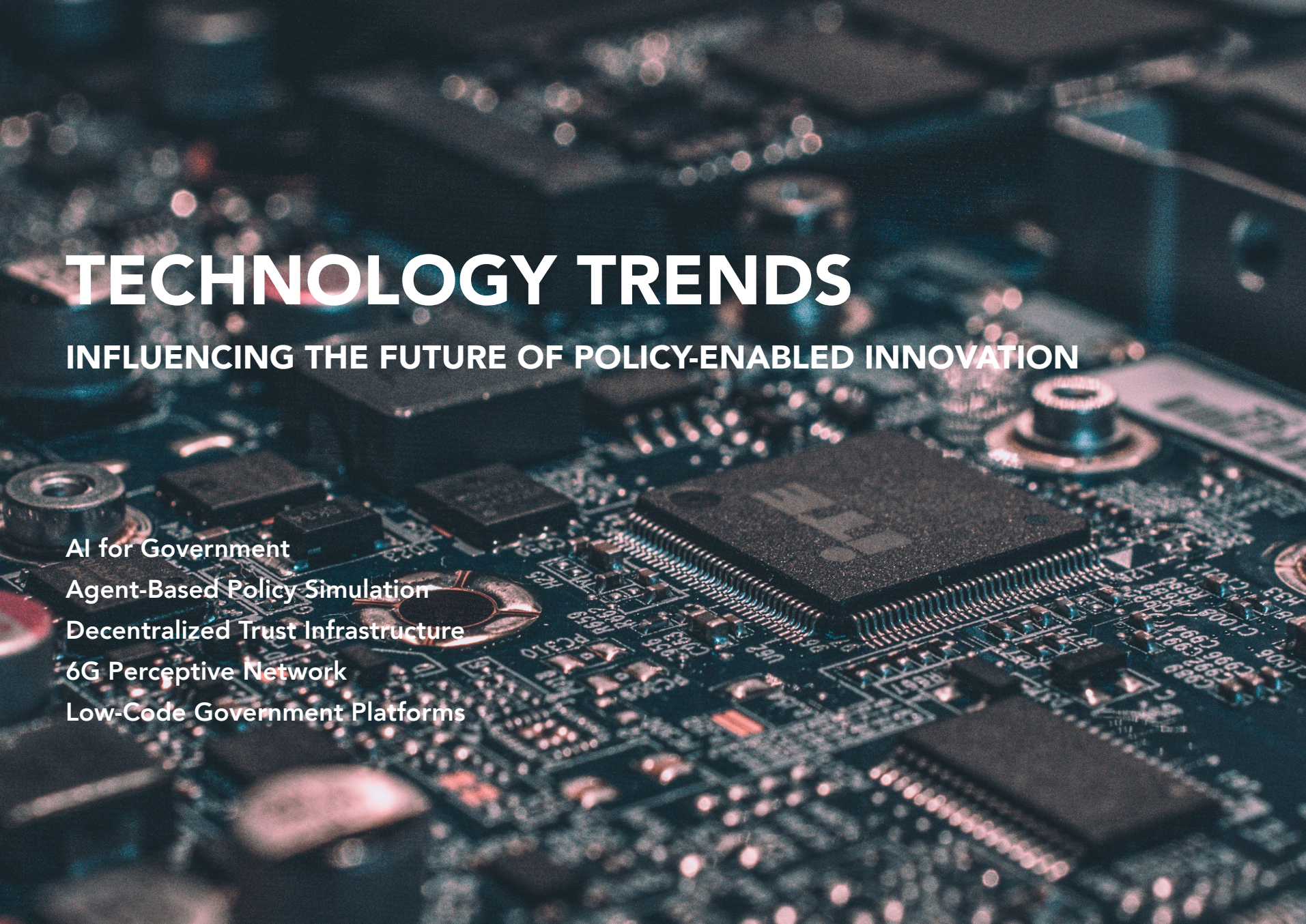
VRE
Variable Renewable Energy

ZKA
Centre for Climate Adaptation

ZKP
Zero-knowledge Proofs

TRENDS

The following chapter lists current trends that have a strong influence on the development and long-term strategic orientation of *The Future of Policy-Enabled Innovation*. In accordance with the Trends Phase methodology, trends and related driving forces are structured into five areas: technology trends, societal trends, legal trends, economic trends, and environmental trends.



TECHNOLOGY TRENDS

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

AI for Government
Agent-Based Policy Simulation
Decentralized Trust Infrastructure
6G Perceptive Network
Low-Code Government Platforms

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TECHNOLOGY TRENDS

Influencing the Future of Policy-Enabled Innovation

When thinking about the most groundbreaking and impactful innovations of past decades, technology is the first thing that comes to mind. It is a powerful flywheel for innovation, driving change, and constantly reshaping industries. In this dynamic landscape driven by technology, policymaking is no exception. Technology trends not only influence how governments operate and innovate but also provide an opportunity for policymakers to shape technological development [1, 2, 3].

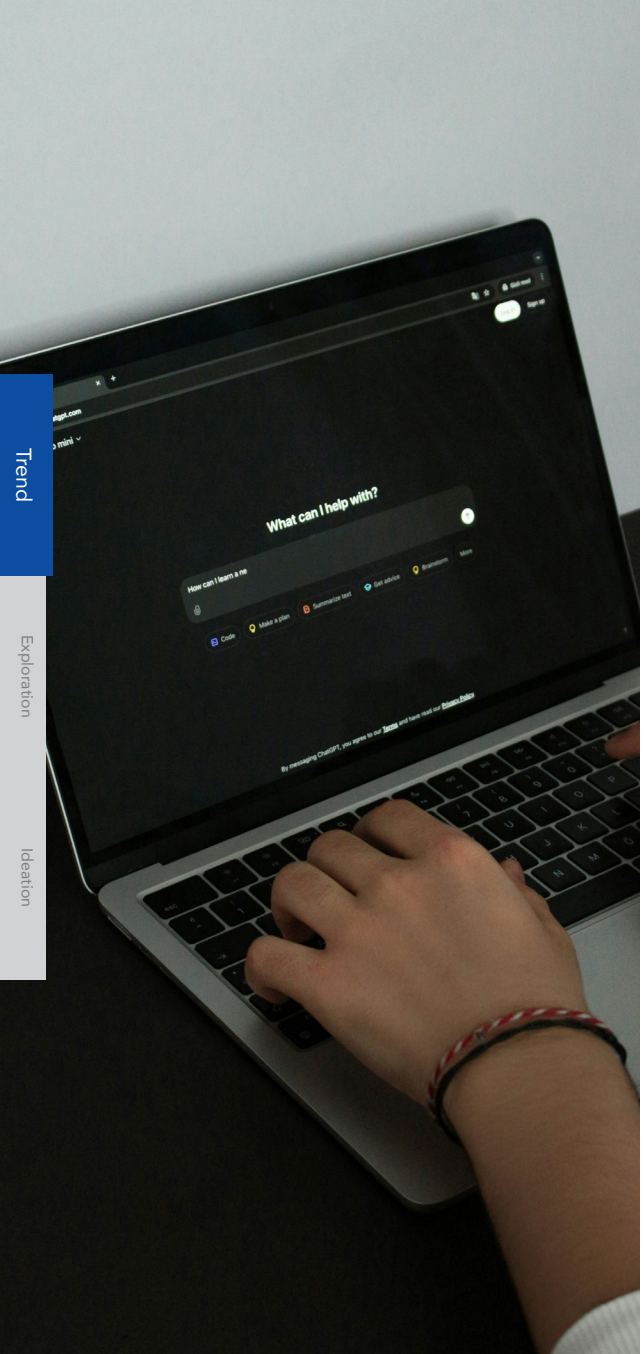
For policymakers, navigating these trends requires adaptation and foresight. On the one hand, governments must ride the wave of innovation, leveraging emerging technologies to enhance governance and public services [3]. On the other hand, they play a critical role in shaping these technologies and how they impact our society and economy [1, 2] – policymakers set the rules, frameworks, and visions that guide technological development, application, and adoption. Successful policymaking with and for technology requires embracing both of these perspectives equally.

Yet, staying ahead in this fast-moving environment demands more than simply following hype cycles. A deep understanding of technology trends is crucial to maximizing the economic and societal upsides of technology [1, 2], avoiding reactionary policies that lag behind the private sector [4] or risk overinvestment in overhyped markets [5], as seen in the current AI boom. While trends like large language models (LLMs) will undoubtedly transform government work [6, 7], this research looks beyond the obvious to explore a broader range of trends that could redefine policy innovation.

The subsequent pages introduce five key technology trends shaping or shaped by policy and governance: the integration of artificial intelligence (AI) into government operations to optimize workflows, automate routine tasks, and enhance citizen engagement; digitalization becoming more accessible through open-source technologies and low-code platforms; the use of agent-based policy simulation to test and predict the impact of regulations; the potential of next-generation 6G networks to improve efficiency and accommodate increasing device connectivity; and advancements in cryptography that enhance scalability and security in digital processes by reducing intermediaries.

Notably, instead of depending on a single breakthrough, technology-driven innovation and its adoption rely on ecosystems that leverage the synergies of the different technological developments [8]. By fostering these ecosystems through policy interventions, public institutions can play a pivotal role in shaping the future of technology.

These technology trends have the potential to drive fundamental change within governance structures. However, their true impact will only be realized when they reach scale. The challenge for policymakers is not just to recognize these shifts but to actively foster their growth, creating a future where governance and innovation evolve hand in hand. By strategically engaging with these trends, governments can shape structural change and lead into an era of policy-enabled innovation.



AI FOR GOVERNMENT

Employing AI Tools for Enhanced Governmental Efficiency and Efficacy

Integrating AI in government operations revolutionizes public administration by enhancing efficiency, effectiveness, and citizen engagement [9, 10]. Advances in AI-driven data analysis and natural language processing (NLP) have paved the way for more data-driven decision-making and innovative public service solutions. AI applications in government range from automating administrative tasks, potentially saving up to 30% of the government workforce's time within 5-7 years [11], to enhancing analytics for better understanding and responding to citizen needs. Digital platforms, such as Reykjavik's "Better Reykjavik" initiative, use AI to classify citizens' thoughts on policies, thereby ensuring policy efficacy [12]. Additionally, AI-powered chatbots like Austria's Mona provide citizens with instant access to government services [10]. Tan et al. found that the perception of AI plays a significant role in determining its usefulness in local government services. Therefore, it is essential for authorities to inform and actively engage citizens in the adoption of AI within local government services [13]. However, while AI presents significant opportunities for improving governance, challenges such as data privacy, algorithmic bias, and regulatory compliance must be carefully managed to ensure ethical deployment [14]. Overall, AI is poised to transform public administration by making policies and government services more responsive, data-driven, and accessible to citizens.

Facts

- Germany ranks eighth out of 193 countries in terms of its government's capacity to integrate AI into public administration in the Government AI Readiness Index 2024 [15].
- OECD's survey of 30 countries showed that 73% (22) of them used AI for public service delivery and internal processes, 37% (11) for policy making, and only 33% (10) across all three areas in 2023 [16].
- European countries have demonstrated resourceful AI use cases. The French AI-based tax audit found 20,000 unregistered buildings, generating 10M EUR in tax revenue [14]. Also, New South Wales has used AI to identify people struggling to pay fines, helping them avoid enforcement actions and access alternative solutions [14].

Key Drivers

- The Online Access Act of 2017 [17] and its update in 2024 [18] mandate that public administration in Germany digitalize the majority of its services.
- Rising citizen expectations shaped by private sector digital experiences are pushing governments to deliver "Amazon-like" service experiences that are seamless, efficient, and accessible [19].
- Advances in AI-driven data analysis and NLP have paved the way for processing large amounts of citizens' feedback automatically, enabling data-driven decision-making [12].

Challenges

- Reliance on legacy IT systems and a shortage of AI expertise, driven by less competitive government salaries, remain a challenge [14].
- Concerns around data privacy, security, and algorithmic bias pose additional hurdles. Regulatory frameworks must evolve to keep pace with AI advancements, ensuring transparency, and accountability in their deployment [14].
- Slow bureaucratic processes and fragmented administrative structures fostered by Federalism in Germany often delay the implementation of nationwide AI-driven initiatives [20].

Impact on the Future of Policy-Enabled Innovation

By using AI to analyze discussions in participatory platforms, policymakers can retrieve essential information about citizens' opinions and concerns, enabling them to design valuable and effective policies. Furthermore, integrating AI into governmental operations and services can significantly reduce the barriers to accessing governmental services and regulations, allowing innovators to easily abide by governmental regulations.

AGENT-BASED POLICY SIMULATION

Harnessing Computational Models for Effective Decision-Making

In today's complex policy landscape, decision-makers need innovative tools for policymaking [21]. A promising tool is agent-based modeling (ABM), which computationally models policy outcomes by simulating how individuals, institutions, and environments interact. It allows policymakers to explore "what-if" scenarios in a safe virtual environment and anticipate outcomes before real-world implementation [22].

However, traditional ABMs often lack sociological depth. Therefore, more advanced computational frameworks like multi-agent artificial intelligence (MAAI) models have been developed. MAAI models use psychologically realistic agents in detailed social networks to create "artificial societies" that better mirror real-world dynamics [23].

While the use of agent-based simulation in policymaking remains limited, there is a growing interest in integrating data-driven tools into political decision-making, with new platforms and models emerging to meet this demand [24]. These tools even transcend outcome prediction by helping policymakers build consensus, understand complex problems, and design evidence-based solutions [25]. As policy challenges grow more intricate, such innovative approaches could play a key role in shaping more effective decisions.

Facts

- The Salesforce AI Economist uses agent-based learning to identify optimal tax policies. Resulting policies increase taxation fairness by up to 16% when compared to tax frameworks considered in academia and outperform current U.S. tax policies [26].
- The UK-based nonprofit PolicyEngine provides open-source software to compute the impact of public policy and has thereby helped shape tax policies in the UK and the US [24, 27].
- Models like VISIBLE, SmartOpenHamburg, and INFSO-SKIN have been used for policy evaluation in education, urban mobility, and funding landscapes [21, 28, 29].

Key Drivers

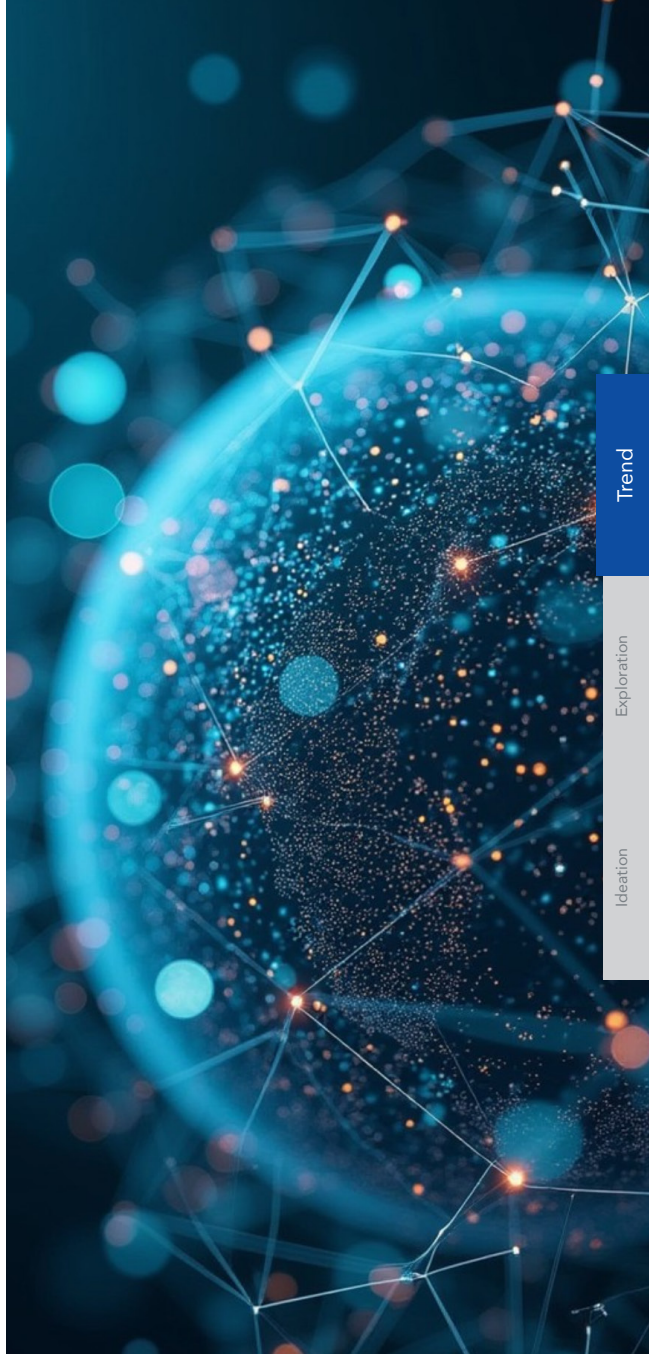
- Advances in Artificial Intelligence (AI) and increased data aggregation enable more realistic, holistic, and complex policy simulations [23]. Combining LLMs with interactive agents could further improve simulation accuracy [30].
- Policy twins, like the one envisioned by the Tony Blair Institute for Global Change, can reduce policy development time [31].
- Federal and local governments increasingly use data-driven and simulated approaches to test and support their policy decisions [24].

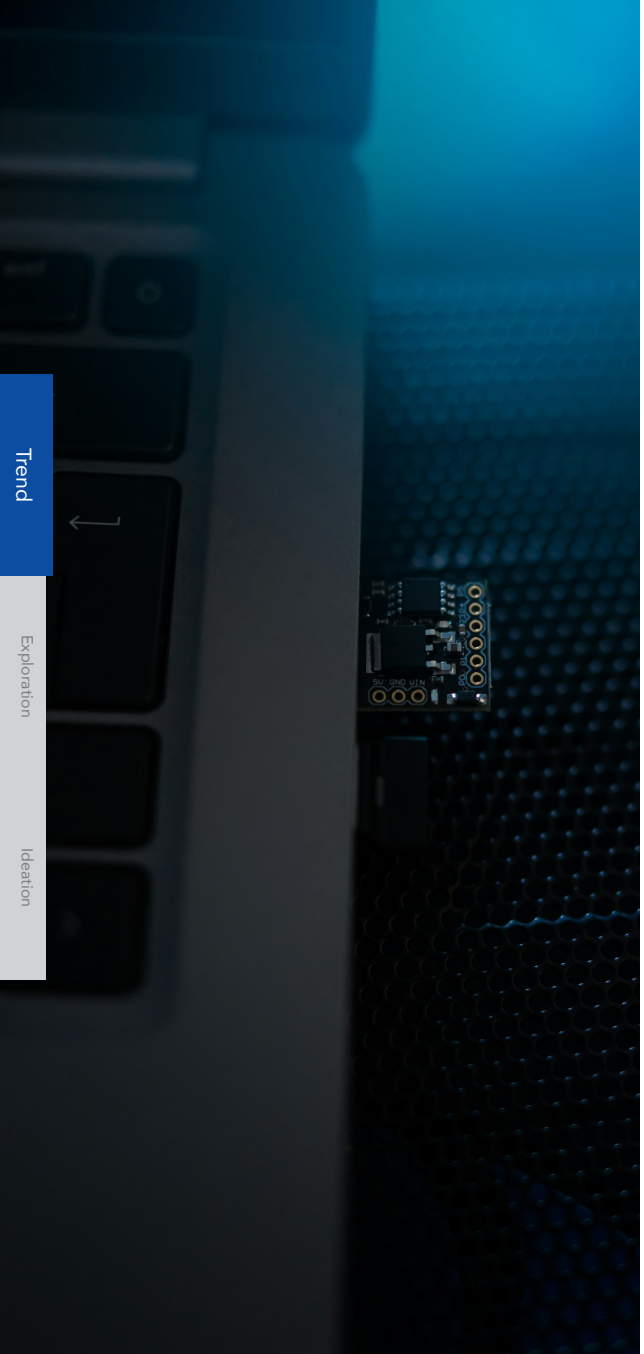
Challenges

- Policymakers often prefer traditional forms of evidence to agent-based simulation. In order to increase simulation credibility, transparency of assumptions, and user-friendliness, policymakers must be involved in and informed about model development [22, 32].
- ABMs and MAAI models require large datasets to simulate social and economic interactions accurately, yet access to high-quality data remains limited. To address this shortage, researchers suggest systematically evaluating open data platforms and using AI to generate synthetic data [21].
- Agent-based modeling still faces technical challenges in modeling the full complexity of policymaking. Prominent examples of complications are the generation of feedback on the policy and striking the right level of detail or abstraction when modeling [21, 32].

Impact on the Future of Policy-Enabled Innovation

By predicting policy outcomes, agent-based simulation facilitates more accurate and effective policies. In tax, research, and innovation policies, simulations already guide efficient public spending to support innovation. For example, the EU INFSO-SKIN project simulated Horizon 2020 funding policies and demonstrated that an increase in SME participation would enhance knowledge exchange and foster innovation networks [28]. Agent-based policy simulation can thus support cutting-edge innovations.





DECENTRALIZED TRUST INFRASTRUCTURE

Cutting Down on Intermediary Parties Through Cryptographic Technologies

Governance and policy often introduce intermediary parties to verify trust: whenever we sign a contract, make a bank transfer, or vote, an intermediary is involved, such as a notary, a bank, or a government office. As a consequence, decision or transaction processes are lengthy.

Decentralized trust infrastructure shortens those processes by replacing intermediaries with cryptographic technologies: blockchains create unchangeable records of transactions [33]; digital identity wallets store personal information [34]; and zero-knowledge proofs (ZKPs) prove the correctness of statements without revealing knowledge [35].

The growing adoption of these technologies encourages policymakers to explore decentralized governance models [36, 37]. Digital identities, for example, materialize to replace notary visits [38], enable e-voting [39], and simplify fragmented verification apparatuses [40].

Looking ahead, Decentralized Autonomous Organizations (DAOs) can power novel governance. DAOs operate without centralized leadership by resorting to blockchain-encoded rules and collective voting. They can be used for distributing funds or suggesting and voting on policy changes [41]. By speeding up decision and transaction processes, cryptographic technologies thus foster adaptive, fast-paced governance.

Facts

- Over 60 countries are already using or piloting e-voting [42], pioneered by Estonia in 2005 [43, 44]. These countries are reaping the benefits of e-voting, like Brazil, which has since seen an increase in valid votes [45]. While in Germany, the federal court has ruled e-voting unconstitutional due to transparency concerns, the court's decision can be revised in light of the increasing societal digitalization [42, 46, 47].
- The European Union (EU) has committed to introducing a European Digital Identity Wallet by 2026 [48].
- The number of DAO participants has skyrocketed in recent years to several million [49, 50].

Key Drivers

- Direct democracy is gaining momentum due to growing dissatisfaction with representative governments, as well as a sense of disconnection and lack of accountability. This shift is evident in the adoption of digital platforms like LiquidFeedback, which facilitates digitally giving feedback to and voting on proposals [51].
- As of 2024, approximately 6.8% of the global population, equating to 562M individuals, own digital currencies. This represents a 34% increase from 2023. The increasing adoption of digital currencies has heightened awareness and trust in blockchain technologies [52].

Challenges

- The highly complex nature of blockchain projects makes their pursuit in public offices difficult: competencies, such as IT and business expertise, are often strictly split across separate authorities. Moreover, a high degree of internal coordination and co-determination stands in the way of iterative, agile development approaches required to handle the technical complexity [53].
- Shifting towards innovative decentralized governance models without intermediaries raises the challenge of preventing an unintended concentration of power [54].

Impact on the Future of Policy-Enabled Innovation

Innovation is often associated with qualities like speed, agility, and diversity of opinion. By using a decentralized trust infrastructure, the government can provide the fast and agile environment required for innovation. First, shared identity platforms and digitally signed certificates can be used to shorten verification and communication processes. Second, decentralized governance mechanisms can shift decisions from a single point of failure to engaged experts with clear remits, thereby considering more diverse inputs and allowing for dynamic policy adaptation.

6G PERCEPTIVE NETWORK

Seeing and Communicating Simultaneously: How 6G Goes Beyond Connectivity

While current cellular mobile networks mainly support communication, future networks will also sense and interpret their environments, detecting objects, movements, and spatial data. Therefore, it is crucial to develop technologies that will increase the efficiency of simultaneous sensing and communication (S&C).

In 5G, S&C are realized in separate modules with limited hardware and knowledge sharing [55]. In comparison, 6G introduces Integrated Sensing and Communication (ISAC), where S&C shares hardware, spectrum, and signal processing [55]. ISAC improves connection density, energy efficiency, and network performance by increasing reliability, localization accuracy, and reducing latency [56, 55, 57]. This raises use cases such as high precision localization, augmented human sense, and gesture recognition [56], pushing progress in fields like smart hospitals and autonomous driving [56, 58].

Given ISAC's pivotal benefits and diverse use cases, extensive research is conducted to prepare for a 6G launch in 2030 [59, 60]. Germany should empower its innovators to be at the forefront of these developments by fostering research and preparing regulatory landscapes.

Facts

- 6G will support significantly more devices than 5G, increasing density from 10M to 100M devices per km² while also being ten times more energy-efficient [56,60].
- The Hexa-X and Hexa-X-II projects, co-funded by the EU, highlight Europe's active role in shaping 6G development [58].
- Machine-to-machine connections reached a total of 14.7B in 2023 – 50% of all connected devices, up from 33% in 2018. Cellular IoT devices are projected to grow from 3.1B to 5B in 2027 compared to 2023, expanding connectivity across cars, buildings, and appliances toward a fully connected world [56, 61, 57].
- Achieving a hundred times 5G's data rates requires new technologies like large-scale antenna arrays, mmWave, and terahertz communication [62, 63, 64].

Key Drivers

- The need for ultra-high data rates and seamless connectivity is straining spectrum limits, requiring expansion beyond 3.6 GHz to 6 GHz and higher [55].
- The widespread deployment of S&C systems is increasing spectrum competition. Traditional separate resource allocation prevents interference but wastes capacity. ISAC enables more innovative resource sharing, improving efficiency and coexistence [55].
- The growing demand for connectivity must align with sustainability goals. 6G could be "sustainable by design," with global organizations (3GPP, ISO, ETSI, ITU-T, GSMA) advocating for greener, more efficient infrastructure [58].

Challenges

- To maximize transmission rates and enhance user experience, the frequency spectrum needs to be allocated resourcefully and uniformly. Responsive national and EU legislation is required to meet these regulatory challenges [58].
- Despite high marketing efforts, consumers did not perceive the value added in the transition from 4G to 5G. Therefore, the communications industry stakeholders are skeptical of how a new 6G infrastructure can be monetized [65].
- Given the unprecedented sensing capabilities of 6G, privacy concerns of citizens and companies need to be addressed [58].

Impact on the Future of Policy-Enabled Innovation

To maintain technological sovereignty, Germany must actively shape the 6G development. Therefore, it must lead in global 6G research, fostering collaboration among key stakeholders. At the same time, a robust 6G infrastructure is essential for businesses to capitalize on new opportunities. By actively shaping policy to address regulatory challenges such as spectrum allocation and privacy concerns, Germany can empower its innovators to be at the forefront of the development and usage of 6G [58, 65].

LOW-CODE GOVERNMENT PLATFORMS

Overcoming Scarce Technical Talent and Costly One-Off Projects With Low-Code Government Platforms

No-code platforms (NCPs) and low-code platforms (LCPs) development is reshaping how government agencies approach digital transformation, particularly in response to challenges such as limited technical expertise and high traditional development costs. These applications empower non-technical staff to independently design, build, and maintain applications, fostering a culture of innovation within public institutions [66]. By reducing the complexity of the development process, LCPs significantly lower the barriers to rapidly deploying new services [67].

Beyond efficiency, LCPs and NCPs reduce reliance on outsourcing by enabling in-house development and enhancing organizational privacy and trust [68]. However, challenges remain, particularly in meeting security requirements and navigating fragmented software landscapes [67, 69, 70]. Despite these hurdles, LCPs and NCPs drive digital transformation in the public sector, improving service delivery [71]. As these platforms evolve, they continue democratizing application development, making it accessible to a broader range of users and accelerating government operations innovations.

Facts

- MODUL-F is a low-code platform enabling the digitization of over 6,000 administrative services affected by the "Onlinezugangs Gesetz" across Germany, providing a way to develop and run simple government applications without technical knowledge [72].
- Gartner estimates that by the end of 2025, more than 35% of government legacy applications will be replaced by solutions developed on low-code platforms [73], reducing the time to build custom applications by 50-90% compared to traditional methods, as seen in enterprises [74].
- Integration of AI enables broader democratization of application development, allowing users to create applications using natural language. For instance, the Swedish AI start-up Lovable allows users to build apps through conversational prompts, currently supporting the daily creation of 25,000 apps [75].

Key Drivers

- Traditional IT projects often exceed their budgets. A 2015 study by the Hertie School, which analyzed 170 large public infrastructure projects in Germany, found that, on average, these projects went over budget by 73%. However, ICT projects faced the largest budget overruns, averaging 394% [76].
- The public sector faces a significant shortage of skilled technical workers, especially in specialized areas like blockchain, due to location constraints and tariff-based salaries [77, 78].

Challenges

- Citizen-developed government applications frequently fail to meet accessibility requirements [79], violating standards such as the European Accessibility Act [80].
- Scalability for complex enterprise applications remains a significant issue, along with fragmented platform standards causing confusion among users [67, 69].
- Inadequate security mechanisms raise concerns over protecting sensitive citizen data and integration with legacy IT systems [81, 82].

Impact on the Future of Policy-Enabled Innovation

Low-code and no-code platforms significantly impact policy-enabled innovation by enabling governments to rapidly deploy digital solutions, thus enhancing public service delivery and responsiveness to citizen needs [71]. For instance, low-code solutions effectively streamlined municipal processes such as liquor license management in Nordre Follo Municipality, Norway. By simplifying routine development tasks, these platforms allow technical staff to concentrate on more complex innovation challenges. Additionally, accelerating policy implementation through low-code tools enables businesses, start-ups, and research institutions to swiftly adapt to regulatory changes, fostering an agile and collaborative innovation environment across various sectors of society [67].

SOCIETAL TRENDS

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

Complexity Overload
Polarized Society
Pessimistic Youth
Education to Navigate the Future
Protecting Social Cohesion

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Carla Appel 
Fabian Hildesheim 
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SOCIETAL TRENDS

Influencing the Future of Policy-Enabled Innovation

Germany's society stands at a crossroads where economic, technological, and political forces require a novel approach to governance. Driven by demographic shifts and fast-evolving digital technologies, rapid social response calls for adaptable policies to address new challenges. At the same time, these societal trends are changing how people grow up, learn, and work, ultimately shaping the nation's identity.

Society is defined as a complex web of institutions, norms, and collective experiences [83]. In Germany, this societal web is uniquely shaped by historical developments such as post–World War II reconstruction and the reunification of East and West in 1990 [84]. These turning points have fostered a shared commitment to democracy and social responsibility, traits often associated with German identity [85]. However, a modern citizen in Germany also navigates an increasingly diverse environment shaped by immigration, globalized markets, and multiculturalism. Hence, contemporary realities are redefining life in Germany.

The World Happiness Report examines people's self-assessed happiness in combination with income, social support, and freedom [86]. By these metrics, Germany consistently ranks within the top 25% of nations, credited with firm social services and robust democratic institutions [86]. However, recent studies indicate growing stress among younger generations, persistent educational inequalities, and deepening social divides. These challenges underscore the role of politics in designing inclusive policies that respond to societal needs and well-being and provide equitable opportunities.

Policy-enabled innovation plays an essential role in addressing these challenges. According to recent government reports, strategic research, education, and technology investments drive economic competitiveness and foster social resilience [87]. When public institutions actively shape the direction of technological and social development, they help create more inclusive, sustainable, and adaptive systems [88]. By steering innovation toward public interests, policymakers can strengthen trust in institutions and nurture a sense of shared purpose across diverse communities.

Young people living in Germany now feel anxious about their future and underrepresented in politics, while schools struggle to embrace digital transformation and ensure educational inclusion and equity [89, 90]. At the same time, immigration infuses new perspectives into knowledge networks, although bureaucratic hurdles and discrimination curtail its impact [91]. Meanwhile, individuals' growing use of information and communication technologies induces information and complexity overload, resulting in feelings of being overwhelmed, confused, or frustrated [92]. Especially in German culture, which values stability and predictability, these feelings can lead to resistance to change and slower implementation of innovations [93, 94]. Adding to these challenges is a growing polarization, particularly between genders, which erodes trust in established institutions [95, 96]. Recognizing these forces is the first step. With forward-looking, transparent policymaking, Germany can leverage the motivation of its youth, incorporate diverse cultural insights, and cultivate an innovation-focused society.

COMPLEXITY OVERLOAD

Increasing Complexity in the Information Age

The world is becoming increasingly complex. This surge in complexity is fueled by the rapid growth of knowledge, interconnectedness, and the ever-accelerating flow of information, mainly through the pervasive influence of social media [97]. While this complexity presents immense opportunities for progress and innovation, it also creates significant challenges for individuals and society. Individuals are confronted with overwhelming information and choices, leading to decision fatigue [98]. This intellectual overload can hinder the adoption of innovations and technologies as people fear that they could introduce even more complexity into their lives [99].

Facts

- In 2023, people in Germany consumed audio and audiovisual media for an average of 9 hours and 46 minutes per day, up from an average of 8 hours and 59 minutes in 2019 [100]. Consuming so much information has consequences; a global survey revealed that 76% of workers report daily stress due to information overload [101].
- The number of papers published globally doubles every nine years [102]. Scientific knowledge is expanding, and the amount of data generated worldwide is projected to reach 182 zettabytes in 2025, up from 41 zettabytes in 2018 [103].
- Due to the complex nature of societal problems, individuals are overwhelmed by the sheer size and complexity of these problems and struggle to address them [104].

Key Drivers

- In 2025, 83% of individuals living in Germany are projected to use social media, up from 60% in 2019 [105]. The consumption mode has also changed, as the competition in the attention economy incentivizes high-frequency, high-intensity information exposure [106].
- People are becoming increasingly reliant on generative AI tools [107]. Several studies link this to a decline in critical thinking skills [108]. Such skills are crucial to navigating a complex world, and lacking them leads to feeling overwhelmed. This can also lead to further reliance on AI systems, creating a negative spiral.

Challenges

- The adoption of technologies that reduce complexity can be a slow and tedious process. Even though technologies promise a more straightforward solution, they often introduce initial complexities the user must navigate. This can lead to people rejecting digital solutions [109].
- The rapid pace of change in the world means that knowledge and certain skills become obsolete quickly, requiring continuous learning and adaptation [110]. This acceleration increases the cognitive load and puts additional pressure on individuals to keep up with ever-changing demands.

Impact on the Future of Policy-Enabled Innovation

The increasing complexity of the information age hinders technology adoption as individuals struggle with cognitive overload and fast change. While promising efficiency, new technologies often introduce initial complexities that deter users. The rapid obsolescence of skills further increases resistance, requiring continuous learning to stay relevant. Policymakers influence this landscape by shaping regulations, digital infrastructure, and incentives that facilitate or slow innovation diffusion. A successful example is the response of the South Korean government to the COVID-19 pandemic. They successfully implemented technological innovations like digital tracing systems, which streamlined crisis response and demonstrated how well-designed policies can mitigate technological complexity [111]. Without clear frameworks, complexity can lead to fragmentation, distrust, and uneven adoption, preventing society from leveraging technological advancements while amplifying disparities between those who can adapt and those who fall behind.

POLARIZED SOCIETY

Rising Political and Gender Divides in a Fragmented Society

Germany is facing a crisis of polarization and disconnection. The 2025 election exposed stark gender divides, with young men favoring conservative parties while women leaned left, reflecting deepening societal rifts [112]. Mistrust in traditional media is surging as digital platforms fuel misinformation shaping political and social perspectives [113]. Economic decline further exacerbates tensions, amplifying fears about the future [114]. Addressing these fractures requires action through policy-driven innovation to restore trust, combat misinformation, and create sustainable frameworks for a more inclusive and cohesive society.

Facts

- In Germany's 2025 election, 42% of young men backed right or center-right wing parties (AfD, CDU/CSU), compared to 24% of young women. Meanwhile, 59% of young women supported left-leaning parties (SPD, Bündnis 90/Die Grünen, Die Linke) versus 38% of young men, highlighting stark gender divides [115].
- Trust in traditional media dropped to 47% (-5%) in 2022, with 75.8% of young Germans distrusting media and 71.6% mistrusting journalists, while 84% view online disinformation as a significant societal issue [116].
- Germany's economy shrank by 0.2% in 2024 after a 0.3% decline in 2023. A 2025 survey found that 68% of Germans see an economic decline as a significant concern, surpassing other issues like migration [117, 114].

Key Drivers

- The increasing reliance on digital and AI-driven news and media ecosystems, coupled with the rise of social media as a primary news source, is re-shaping public trust while also amplifying the spread of misinformation and conspiracy thinking [118].
- With women comprising 50.9% of university enrollments in 2023/2024 in Germany [119], their rising educational attainment is associated with increased attention to the gender pay gap and male dominance in leadership positions [120]. This, in turn, deepens polarization between gender equality advocates and conservative opposition, pushing political parties to realign their strategies for an electorate increasingly divided between feminist and anti-feminist movements.
- Algorithm-driven content silos reinforce ideological divides, weakening familiar societal narratives. As trust in institutions declines, polarization deepens, hindering consensus-driven policymaking and fostering disengagement from democratic processes [121].

Challenges

- A persistent gender gap in leadership and high-paying industries, combined with growing political polarization between men and women, threatens social cohesion and hinders progressive change, as male-dominated leadership increasingly aligns with conservative views, resisting initiatives for greater gender equality [122].
- Balancing efforts to rebuild public trust in media while combating misinformation is challenging. State intervention may deepen distrust, and overly restrictive measures on social media risk undermining free expression or driving misinformation to alternative platforms.

Impact on the Future of Policy-Enabled Innovation

Growing polarization and declining trust in institutions make consensus-driven policymaking increasingly difficult, posing significant challenges for policy-enabled innovation. Policymakers need to address polarization, but imposed policies risk deepening mistrust. Full transparency is vital to rebuilding and sustaining public trust [123]. At the same time, clear guidelines for emerging technologies like AI, which influence society and media, are essential to ensure their responsible use and seamless adaptation. Initiatives like "Deutschland Spricht" offer a promising solution by fostering dialogue across political divides, helping to bridge societal gaps, and creating a more open, collaborative environment for policy innovation [124].

PESSIMISTIC YOUTH

Empowering Young People to Overcome Pessimism and Shape the Future

Young people in Germany are increasingly pessimistic about the future. Recent studies highlight a notable decline in optimism among people under the age of 30, with many expecting their generation to face more challenging times than their parents [125]. Multiple crises, from the COVID-19 pandemic to the war in Ukraine and climate change, have shaken the youth's confidence in a stable future. At the same time, young people feel strong social responsibility and are eager to participate in political debates [126]. Anxiety about economic security and political frustration makes young people feel overlooked by the system and jeopardizes their engagement [127].

Facts

- Pessimism about the future is common among young people in Germany. The World Happiness Report reveals that Germany ranks 47th in happiness among under 30-year-olds, while the remaining population ranks 19th-24th in international comparison [128].
- Germany's youth is interested in politics and social debate; their willingness to get politically involved has increased by 15% between 2002 and 2024 [126].
- Gen Z prioritizes social responsibility. In Bavaria, people aged 14-20 have the highest volunteering rate (49%) [129]. Nationally, voluntary engagement among young people increased by 10% between 2009 and 2019, the most considerable increase among all age groups [130].

Key Drivers

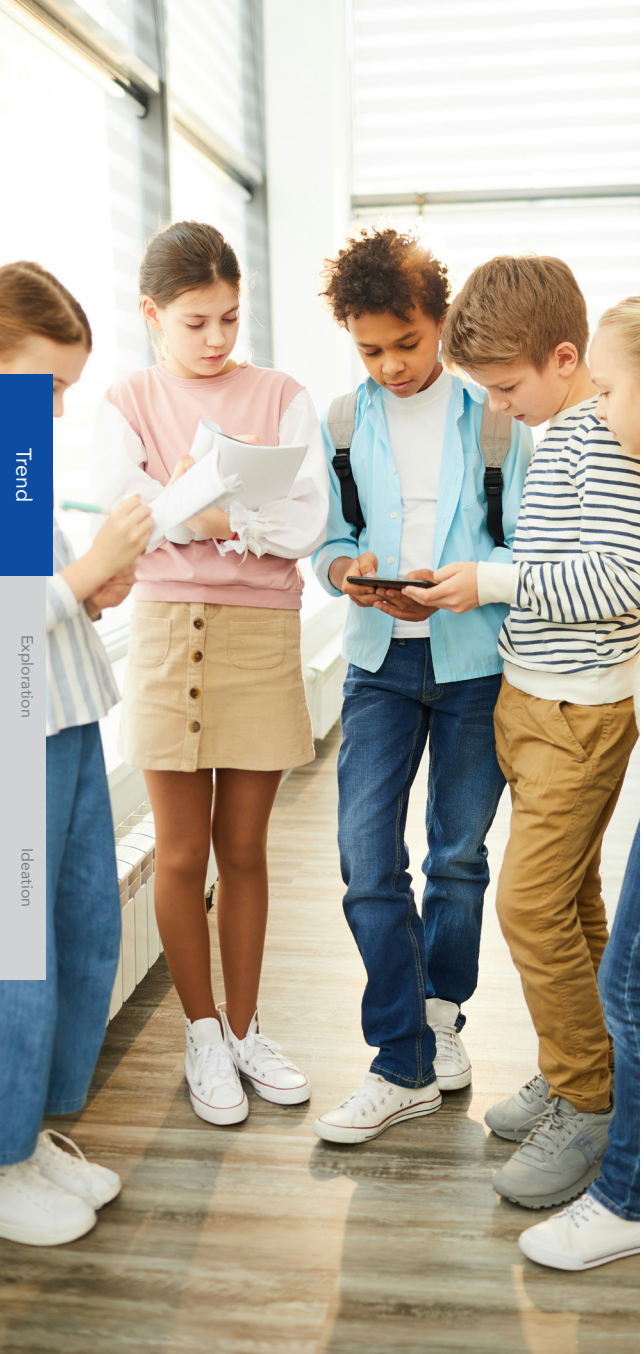
- In 2024, 51% of people aged 14-29 reported feeling stressed about their future: 36% felt exhausted while 17% felt helpless, levels that increased over the past three years. 65% of respondents worry about inflation eroding their living standards, and 54% are concerned about unaffordable housing [125].
- 72% of young people (14-24 years) are unsatisfied with how politicians represent their concerns and interests [131]. Despite strong interest in politics, only 45% believe they can influence politics, and 50% think their political engagement does not achieve much [132].
- First-hand experience with multiple crises drives youth activism and a strong belief in collective action to address challenges like climate change and discrimination [127].

Challenges

- Young people want fast change and only see this happening with extreme parties: 52% of people aged 18-24 voted for Die Linke, Bündnis Sahra Wagenknecht (BSW), or for the Alternative für Deutschland (AfD) in the German federal election in February 2025 [133].
- The average age of current parliament members is 47: 44.1% are above 50, while only 5.1% are under 30, failing to represent the 13.3% of voters under age 30 [134, 135].
- Young people feel that schools lack education on politics and democracy and opportunities for democratic participation [127]. At the same time, 58% turned to social media platforms for political information and 85% used social media to find out more about the 2021 German election campaign or to share political content, despite being concerned about fake news and filter bubbles [136, 127].

Impact on the Future of Policy-Enabled Innovation

Germany misses unique perspectives, creativity, and innovation potential by failing to give young people sufficient influence. Since young people are eager to get involved politically, policies must enable them to engage in discussions, leverage their activism, and allow them to shape solutions [137]. To better represent interests in politics, the Youth Strategy of the Federal Government was launched in 2019 [138]. The initiative, for example, supports research on youth behavior and interests, organizes youth politics days ("Jugendpolitik Tage"), and offers career orientation programs [138]. Using policy to provide opportunities for young people to contribute ideas can boost their optimism and creativity and drive innovation.



EDUCATION TO NAVIGATE THE FUTURE

Falling Behind in Technology Adoption and Psychological Safety in Schools

Germany's education system is under pressure as rapid technological advancements, rising mental health concerns, and persistent social disparities demand a significantly more future-focused approach [90, 139]. However, many schools rely on outdated methods, lacking the digital infrastructure, teaching staff, and support structures necessary to equip students with the skills to face modern challenges [140]. PISA test scores further highlight that students in Germany are performing poorly in math, reading, and science compared to other countries [141]. This gap underscores the urgency for transformative reforms in education, prioritizing innovation, well-being, and inclusivity.

Facts

- The IGLU 2021 report found that over 25.4% of fourth-graders lack sufficient reading skills, a sharp increase from 18.9% in 2016 [142].
- Using artificial intelligence (AI) for personalized education has been shown to improve learning outcomes by 25% [143]. However, 83% of German schools lack a consistent approach to incorporating AI in the classroom [144].
- Whilst 21% of all students show psychological anomalies, 75% of those students suffer from significantly lower life quality. Furthermore, close to one-third of students feel uncomfortable in school [145].
- Socioeconomic background strongly influences educational outcomes in Germany, with a 111-point gap in math scores between advantaged and disadvantaged students, one of the largest in the Organisation for Economic Co-operation and Development (OECD) countries [141].

Key Drivers

- Teacher shortages and underdeveloped digital infrastructure are obstacles to implementing personalized education, delivered in person or using AI [146].
- Increasing amounts of students feel psychological pressure and anxiety through wars, performance expectations, and uncertainty about their future [147].
- The share of ninth graders with a migration background in Germany increased from 29% in 2015 to 38% in 2022, posing an increasing need for tailored educational policies to support integration and ensure equal opportunities [148].

Challenges

- Germany is projected to face a shortage of 80,000 teachers by 2030, impacting the implementation of individualized education. With fewer teachers, class sizes increase, making tailored learning even more challenging [149]. Furthermore, many teachers lack training in digital tools and personalized teaching methods [150].
- Digital infrastructure varies significantly across schools, creating disparities in access to technology-enabled learning. While some schools have modern equipment, others lack essential digital resources. Only 56.7% of fourth-graders have access to one computer per two students, below the EU (67.6%) and OECD (67.5%) averages, potentially widening educational inequality [137].

Impact on the Future of Policy-Enabled Innovation

Education and innovation are interlinked in two ways. First, a stronger education system enhances learning outcomes, equipping individuals with the skills to drive technological progress and strengthen the economy. Second, policies must enable innovation within the system through AI-driven tools, robust digital infrastructure, and comprehensive teacher support to ensure more adaptive and inclusive learning. Addressing these aspects is crucial to equip Germany's youth with the skills necessary to excel in the future workforce, reduce educational and social disparities, and build a resilient and adaptable educational system.

PROTECTING SOCIAL COHESION

Fostering Social Inclusiveness to Enable Innovation

Social cohesion enhances equal participation in society by fostering acceptance of diversity, trust in institutions, and shared responsibility [151]. However, world crises such as war, inflation, and rising political polarization have put Germany's social cohesion under strain [152]. These causes are leading to disparities in social participation and economic opportunities, which in turn create barriers to innovation [153]. As a result, innovation is required beyond its conventional emphasis on technical and economic metrics to include social considerations such as social inclusiveness [154, 155]. Given the extent of existing and emerging societal issues, Germany's innovation framework should integrate social inclusiveness more into the technological advancements to address societal challenges effectively [156].

Facts

- In 2023, 79% of people in Germany agreed with the statement that everyone looks only after themselves, up from 55% in 2020 [156].
- In Germany, migrants with foreign qualifications, despite having literacy skills comparable to their native peers, are at least three times more likely to be overqualified for their jobs, a disparity driven by a lack of social inclusivity [157].
- After the COVID-19 pandemic, 36% of 18-53 year olds feel lonely, 39% are unhappy with their social surroundings, and 29% are missing close connections [158].
- In Germany, 62% of citizens are regularly concerned about national social cohesion [159].

Key Drivers

- The decrease in the sense of community is driven by multiple factors, ranging from exposure to numerous concurrent crises, the aftermath of the COVID-19 pandemic, a decline in solidarity, weaker local connections, and a growing social divide [160].
- Digital lifestyles also reshape how people form and maintain relationships. As communication shifts to online platforms and remote work increases, face-to-face interactions decline, weakening social bonds, political participation, and civic and cultural engagement [161].

Challenges

- Short-term public acceptance of migrants decreased in 2023 due to economic anxieties, housing pressures, and political tensions, fueling support for anti-immigration parties like the AfD [162].
- Societal groups are unevenly affected by the drivers. Low-income and marginalized groups, such as single parents, are disproportionately disadvantaged, making it harder to include them in a cohesive society [163].
- Social innovations typically impact large parts of society, which require buy-in from the public and typically involve lengthy processes to establish them [164]. In a fragmented society, this is increasingly difficult to achieve.

Impact on the Future of Policy-Enabled Innovation

A cohesive and inclusive society is vital for Germany to sustain innovation and attract talent, providing the stability and trust needed to attract economic investment [165], which is a key pillar of innovation [166]. Further, communities with strong trust networks are more resilient during crises like COVID-19, demonstrating a greater capacity to adapt and align with public response measures [167]. Finally, social inclusiveness and equal access to opportunities are essential for innovation. They ensure a diverse range of perspectives, ideas, and talents are brought together, driving creativity and fostering groundbreaking solutions that can address complex global challenges [168].

LEGAL TRENDS

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

Increasing Efforts to Reduce Bureaucracy
Return of Domestic Industrial Policy
Rise of Regulatory Sandboxes
Government Venture Capital Surge
Skilled Worker Visas Expansion

Izabella Pavlova 
Julian Ehrenbrandtner 
Maaz Ahmed 
Sven Ader 
Vishwa Singh 

LEGAL TRENDS

Influencing the Future of Policy-Enabled Innovation

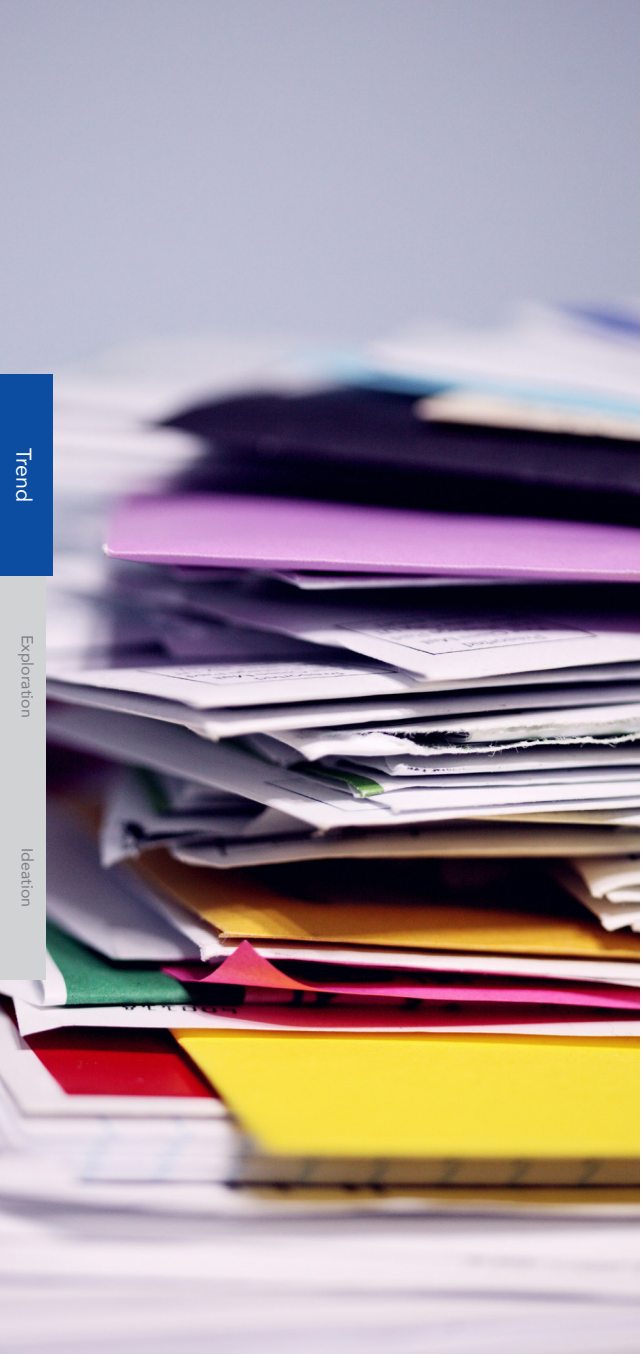
The interplay between policy and innovation is undergoing a profound transformation. Governments are actively shaping the trajectory of technological advancement through targeted legal and policy frameworks [169]. Germany's Growth Opportunities Act [170] and the 12B EUR WIN Initiative [171], designed to bolster the startup ecosystem, are evidence of this shift. However, these developments unfold in a complex global context where the retreat from globalization reshapes trade dynamics. The urgency of decarbonization and accelerating digitalization challenge existing regulatory frameworks, all of which require a nuanced understanding of the legal landscape.

From a legal standpoint, policy-enabled innovation involves strategically deploying governmental regulations to purposefully drive technological and economic progress. This relationship is inherently reciprocal: while policies shape innovation, emerging technologies and market dynamics compel governments to adapt their legal frameworks. Consequently, several key policy trends are reshaping the innovation landscape. One prominent trend is the resurgence of domestic industrial policy, as nations seek to reduce reliance on global trade by supporting local industries. This is exemplified by initiatives like the U.S. CHIPS and Science Act and the EU's IPCEI initiative, which utilize subsidies, tax incentives, and direct investments to foster leadership in critical sectors [172].

Another trend is the prioritization of bureaucracy reduction. Governments are streamlining regulations, reducing red tape, and digitizing services to enhance efficiency and foster innovation [173]. These efforts aim to free businesses from administrative burdens, allowing them to focus on innovation. Regulatory sandboxes are also gaining prominence, offering controlled environments for testing new technologies under flexible regulations [174]. Initially targeting the financial sector, sandboxes now extend to areas like AI, health tech, and energy, facilitating mutual learning between innovators and regulators [175].

Furthermore, the expansion of skilled worker visas reflects the recognition of talent as a critical driver of innovation. In response to global competition, nations are revising visa policies to attract top talent in fields like tech and science. [176] Programs like the UK's High Potential Individual Visa and Canada's Startup Visa are designed to integrate skilled workers into local innovation ecosystems [177]. Finally, government venture capital is transforming the funding landscape for high-risk, transformative innovations. Governments are stepping in where traditional venture capital hesitates, providing crucial financial support for deep tech and clean energy projects. These investments bridge the gap between research and commercial viability, driving long-term growth in critical industries [178].

Though beneficial, these policy trends raise concerns not only about preserving market stability and fair competition but also about the emergence of additional risks, including protectionist tendencies. In today's interconnected global economy, such risks extend beyond national borders, prompting complex legal questions around international trade and the need for stronger cross-border cooperation. Policymakers must, therefore, take the lead in shaping legal frameworks so that innovation policies remain fair, transparent, and adaptable as technological progress continues.



INCREASING EFFORTS TO REDUCE BUREAUCRACY

Bureaucracy Reduction Acts are Gaining Momentum Among Governments

In an era where administrative efficiency directly impacts economic competitiveness, Germany loses an estimated 146B EUR annually due to excessive administrative burdens, commonly referred to as "red tape" [179]. Beyond productivity losses and burdensome administrative tasks, bureaucratic inefficiencies have also discouraged significant investments in Germany [180]. The challenge is not unique to Germany, as bureaucratic inefficiencies affect economies worldwide. Recognizing this problem, governments across the globe have stepped up efforts to cut administrative red tape through legislative reforms [181]. Many countries are already seeing promising results: Estonia's full digitization of government services saves 1,400 working years annually [182]. At the same time, South Africa's reforms have reduced the corporate income tax audit process from 32 to 17 weeks [181]. By learning from these global best practices, Germany has the opportunity to reduce bureaucratic complexity and create a more innovation-friendly environment.

Facts

- Canada pioneered bureaucracy reduction with its 2012 Red Tape Reduction Action Plan that introduced a one-for-one rule: for every new regulation, an existing one must be removed [183].
- Similarly, China (2022) streamlined business license approvals [184], while the UAE's Zero Government Bureaucracy program is even more ambitious, requiring ministries to eliminate over 2,000 government measures by the end of 2024 [185].
- In 2023, the EU introduced the SME Relief package to ease burdens on small and medium enterprises [186].
- Germany aims to save 3.6B EUR by 2025 in bureaucracy costs with "Entwurf für ein Viertes Bürokratieentlastungsgesetz" (BEG IV) [187].

Key Drivers

- Excessive bureaucracy imposes substantial economic burdens on nations, undermining their global competitiveness [188]. In the US alone, regulatory compliance, and administrative red tape cost the economy approximately 3.1T USD annually, equivalent to 12% of the country's GDP [181].
- The widespread adoption of digital services in everyday life has raised expectations for similar efficiency in public administration [189], especially since COVID-19 [190, 191].
- The fast-evolving market is causing bureaucratic costs to grow faster. For example, the annual compliance cost for German businesses increased from 17.4B EUR to 26.8B EUR in 2022/23 [192].
- For many European SMEs, staying compliant becomes a growing challenge due to the combined weight of national and EU-level regulations [193].

Challenges

- Progress on regulatory relief in Germany has been slow. Only 105 of the 575 services mandated by the Online Access Act have been implemented [194], and nearly 70% of businesses believe BEG IV will bring only marginal improvements [193].
- Germany sees relatively little personnel exchange between government and business [195]. Without exposure to the realities of business administration, policymakers often struggle to design effective reforms to reduce red tape [193, 194].

Impact on the Future of Policy-Enabled Innovation

Government efforts to reduce the bureaucratic burden on their domestic economies have several positive impacts on innovation. Reduced bureaucracy enables quicker implementation of innovative ideas and more efficient testing of new solutions [196, 197]. It also frees up financial and human resources for innovation. 75% of industry experts consider it a crucial prerequisite for accelerating innovation [198]. These efforts further drive the digitization of administrative processes, enabling more efficient governmental service delivery [199].

RETURN OF DOMESTIC INDUSTRIAL POLICY

Reducing Global Trade Dependency Through National Industrial Strategies

In recent years, governments significantly increased the scale of domestic subsidies [200], unveiling substantial subsidy programs, tax breaks, and laws to foster local industries and R&D [201, 202, 203]. The US CHIPS and Science Act is exemplary in subsidizing domestic semiconductor manufacturing and R&D [172]. This push towards national industrial strategies also appeared elsewhere: the EU established IPCEI (Important Projects of Common European Interest), subsidizing R&D, and innovation in key industries like batteries, microelectronics, and hydrogen [204]. Germany set up a national hydrogen strategy in 2020 and extended it in 2023, investing billions to lead in this technology [205]. Asian countries followed suit. For example, South Korea introduced the 2023 K-Chips Act, providing domestic development and production subsidies through special tax credits [206].

Facts

- The 2022 U.S. CHIPS Act allocated 200B USD for R&D to spur breakthroughs in quantum computing and AI [207].
- The EU Chips Act seeks to mobilize 43B USD to "strengthen Europe's technological leadership" by 2030 [208].
- Germany committed 2B EUR to quantum computing research, aiming for a "Made in Germany" quantum computer by 2025 [209].
- Under IPCEI on hydrogen, Germany pledged over 8B EUR for 62 domestic hydrogen projects [210].

Key Drivers

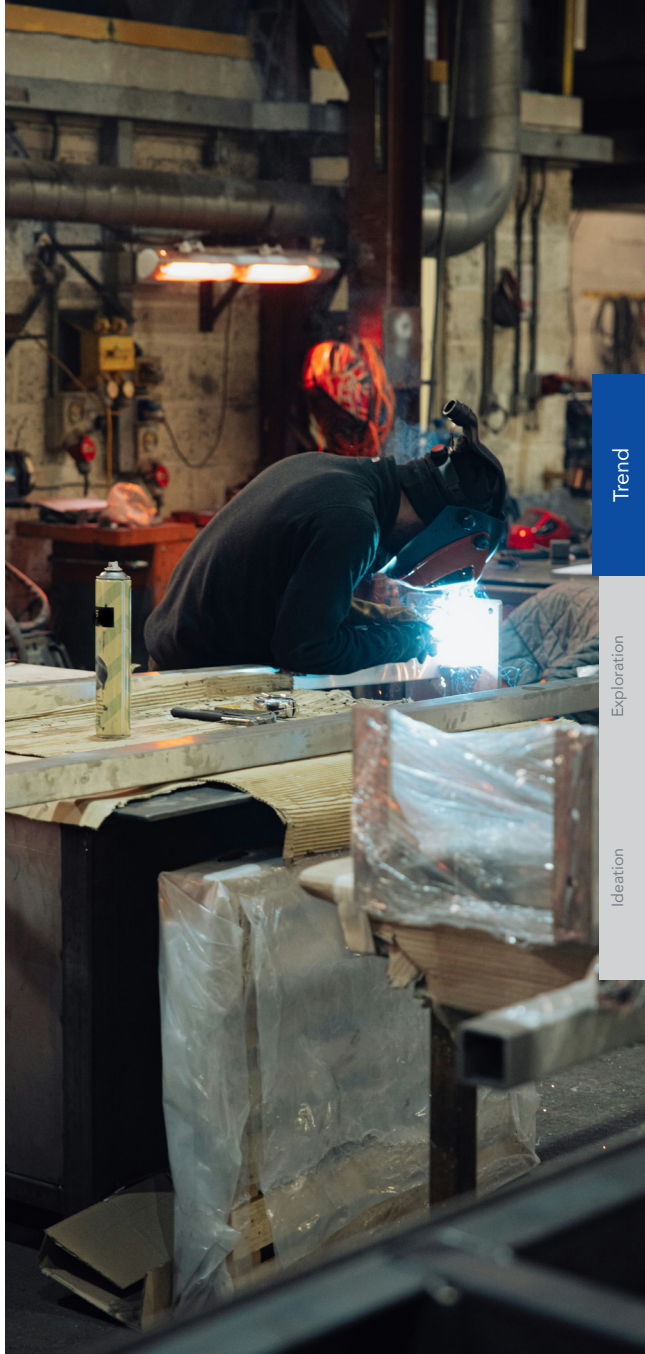
- In light of the war in Ukraine, the US's shifting political stance, and other geopolitical developments, governments worldwide aim to secure domestic control over key technologies for crises or political stand-offs [211, 212, 213].
- After supply chain disruptions following the COVID-19 pandemic, many policymakers are seeking ways to strengthen the resilience of their supply chains [214]. Further, nationalist movements urge governments to revive manufacturing jobs by localizing the production of essential products [215].
- Nations increasingly view technological leadership as essential for long-term economic power, particularly in rapidly evolving sectors like AI, battery technology, biotechnology, semiconductor manufacturing, space exploration, satellite technologies, and clean energy [212, 216, 217, 218].

Challenges

- The deglobalization policies contrast sharply with the interconnected economy of the last decades and lead to new trade tensions. International trade rules are violated by these policies, as EU leaders accused the US of breaking the World Trade Organization principle of non-discrimination of domestic and foreign products [219]. It is expected that subsidies have affected global trade more negatively than tariffs since the 2008 financial crisis, though calculating the individual impact of trade measurements is challenging [220].
- Economists such as Jagdish Bhagwati warn that domestic subsidy policies can cause inefficiencies and market distortions. This development could attract inefficient suppliers [221], raise end consumer prices, or create an oversupply of specific technologies – ultimately wasting public funds [222].

Impact on the Future of Policy-Enabled Innovation

The unprecedented allocation of public resources for innovation and key technologies has the potential to accelerate their development dramatically [220]. Historically, these policies are followed by a surge in private investment [223, 224], which is why EU policymakers approved 8.7B USD of public funds for 5G/6G telecommunications technology, autonomous driving, AI, and quantum computing, hoping to attract another 13.7B USD in private funding for these technologies [225]. These policies also impact regulatory approvals; for example, the EU temporarily loosened EU state-aid controls to enable a faster roll-out of innovation projects [226].



RISE OF REGULATORY SANDBOXES

Bridging the Gap Between Regulation and Technological Innovation

Regulatory sandboxes are controlled testing environments where companies can experiment with innovative products or services under a regulator's supervision and relaxed legal requirements. They allow highly regulated industries such as FinTech, health tech, energy, mobility, and AI innovators to trial new ideas on a limited scale without immediately facing full compliance. Pioneered by FinTech regulators in the UK, sandboxes have since spread globally and across sectors. [227]

They enable mutual learning: firms get early feedback and regulatory clarity, while authorities observe emerging technologies and can adjust policies and legislation accordingly [228].

Facts

- Since the UK FCA launched the first prominent regulatory sandbox in 2016, over 50 countries have implemented similar frameworks [229], with the USA, Singapore, and the UK accounting for 25% of global sandboxes [230].
- Companies participating in regulatory sandboxes raise 15% more capital on average and are 50% more likely to secure funding. They also generate significantly more patents and are more likely to still be operating two years later than comparable firms [231].
- The recent EU AI Act requires every member state to set up a regulatory sandbox to support the safe and responsible development of AI technologies [232, 233].
- Germany has also adopted regulatory sandboxes (known as "Reallabore") for piloting hydrogen integration into energy networks [234] or for testing climate-neutral industrial processes [235]. Furthermore, efforts are underway to expand these initiatives with clearer legal frameworks and more streamlined approval procedures [236].

Key Drivers

- Due to limited internal expertise, regulators frequently struggle to assess the complexities of emerging technologies and increasingly rely on partnerships with academic institutions and industry experts to bridge this gap [237].
- Technological innovations outpace existing regulatory frameworks, leading regulators to seek flexible oversight mechanisms that still allow for innovation [238, 239, 237]. Regulatory sandboxes offer a practical tool to better understand these advances and contemplate the required regulatory adjustments [240].
- Leading innovative companies often have the flexibility to choose where they operate and, therefore, favor regions with flexible, supportive regulation. In the FinTech industry, for example, this trend has led to competition among financial centers to become as business friendly as possible [241].

Challenges

- Establishing and managing regulatory sandboxes requires significant resources, including skilled personnel and technological infrastructure. Additionally, limited spots per sandbox can create unfair competitive advantages, distorting market dynamics [239, 242].
- While sandboxes promote innovation, they also pose scaling challenges since the controlled setup differs from actual market conditions [243], and regulatory fragmentation across jurisdictions hinders them from scaling internationally fast [244].

Impact on the Future of Policy-Enabled Innovation

Regulatory sandboxes represent a fundamental shift in how policies are designed and implemented. As technological innovation continues to accelerate, these flexible regulatory frameworks are set to rise in importance [245].

With their success in fast-tracking innovations such as FinTech in Singapore [246] and cultivated meat in the UK [247], regulatory sandboxes are becoming an essential governance tool for balancing innovation advancement with public safety and welfare considerations [248].

GOVERNMENT VENTURE CAPITAL SURGE

Driving Innovation through Strategic Public Funds, Leveraging Private Co-Investment for Success

Venture Capital (VC) firms traditionally prioritize digital and consumer technologies for quick, cost-effective scalability, often overlooking riskier, capital-heavy "deep technologies" such as advanced manufacturing and biotechnology that require longer maturation periods [249]. Government Venture Capital (GovVC) has thus emerged as a fast-growing global policy tool to bridge this funding gap, supporting high-risk, transformative innovations with substantial social and economic potential [178]. Inspired by the U.S. Defense Advanced Research Projects Agency (DARPA), which pioneered technologies like weather satellites, GPS, drones, and personal computers [250], GovVC models are adopted worldwide. Although OECD research suggests GovVC-funded firms may initially underperform, especially in securing follow-on funding, co-investment with private partners significantly improves performance, underscoring the efficacy of public-private venture funding partnerships [178].

Facts

- After establishing a 260M USD Innovation and Technology Venture Fund in 2017, Hong Kong reallocated 190M USD to establish co-investment funds with the private sector [251].
- The U.S. Department of Defense launched the National Security Innovation Capital in 2021 to address the lack of private venture capital funding for developing new hardware technologies with commercial and national security applications [252].
- The European Innovation Council will invest 1.4B EUR in deep tech in 2025, including 300M EUR through the STEP Scale-up scheme, aiming for 50-150M EUR with private co-investment [253].
- Launched in 2019 as a non-military counterpart to the US DARPA, Germany's SPRIN-D (Federal Agency for Disruptive Innovation) manages a 1B EUR, 10-year budget for high-risk, early-stage projects that lie beyond the reach of private investment [254].

Key Drivers

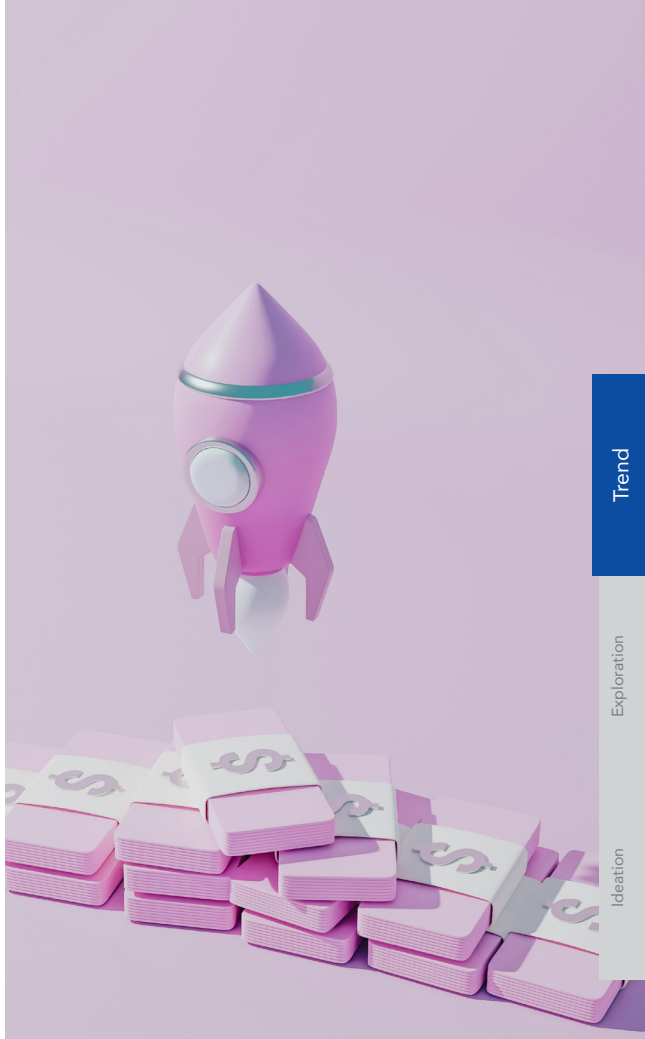
- Private VCs traditionally prefer digital and consumer technology investments that promise quick profits while avoiding costly, long-term commitments to deep tech and hardware ventures in sectors like energy. Governments step in to provide capital for these riskier sectors, aiming to attract private investment at later stages [249, 178].
- Governments increasingly regard specific technologies as critical for economic competitiveness, national security, and tackling societal issues. They use co-investment to steer development in priority sectors, as seen with Germany's DeepTech & Climate Fund co-investing up to 1B EUR in high-tech startups [255].

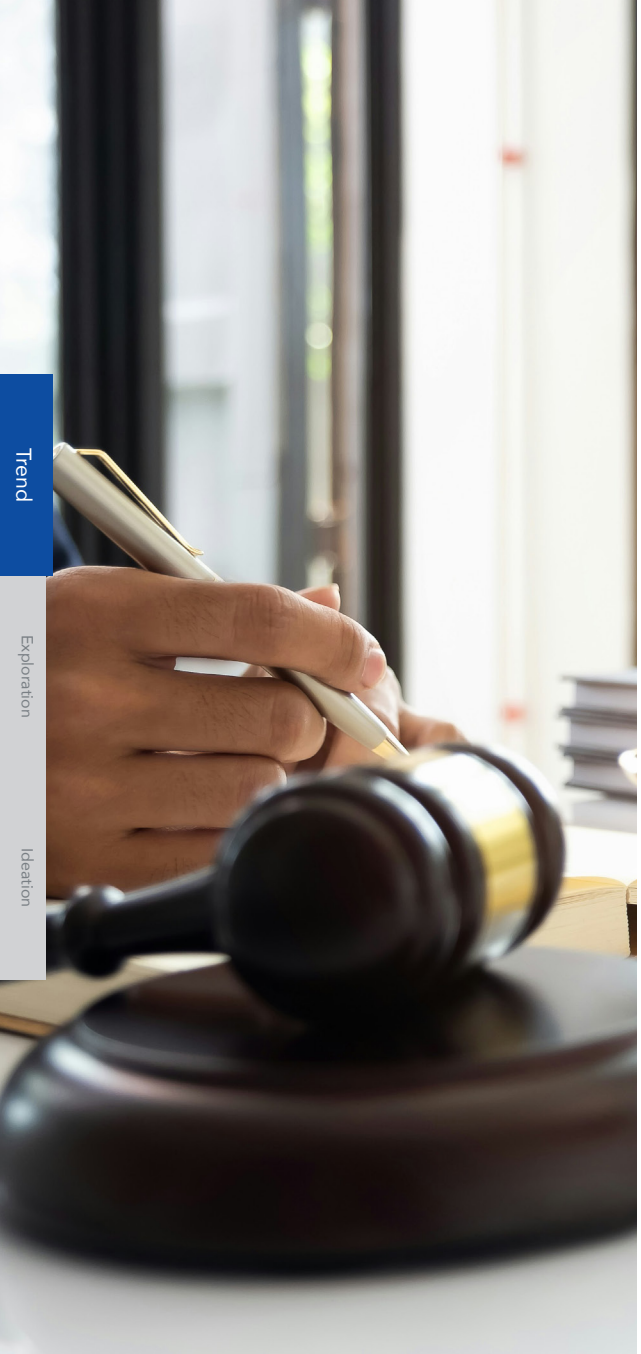
Challenges

- Lacking traditional VC expertise, governments frequently face challenges in selecting promising technologies without distorting markets or backing unviable projects. OECD research supports this concern, indicating that firms solely funded by GovVC tend to have worse financial outcomes than those with private or co-investment [178].
- Political biases can lead governments to favor businesses with political connections rather than truly innovative companies [256], and when investments fail, they often face public criticism for wasting taxpayer money [257].

Impact on the Future of Policy-Enabled Innovation

Strategic government investment targets the "valley of death" funding gap between research and commercial viability for high-risk technologies, reshaping informational, regulatory, financial, and market conditions to lower risk and boost certainty for firms and private investors [178]. Notable successes include DARPA's role in technologies behind Apple's Siri [258] and SPRIN-D's support for deep tech and cancer therapy in Germany [259]. However, poorly designed government intervention without sufficient technical expertise may reduce returns [260], while well-structured GovVC and co-investment programs generate spillover effects, influencing industries or regions and enhancing startup financing policies [256].





SKILLED WORKER VISAS EXPANSION

Relaxing Visa Policies to Attract Skilled Professionals and Decrease Talent Shortages

Countries like Germany, the Netherlands, and Belgium, whose economies are driven by technological advancements rather than resource extraction, recognize the strategic importance of attracting high-skilled professionals to remain competitive through innovation [261, 262, 263]. Research shows that the concentration of R&D professionals within a region's workforce is strongly correlated with increased innovation activity [264]. In 2024, Germany faced a shortage of over 530,000 qualified workers, underscoring the urgent need for skilled labor in key industries such as healthcare and construction [265].

While Germany is still in the early stages of implementing immigration reforms, other countries have already introduced targeted visa programs for international graduates, skilled professionals, and entrepreneurs [266, 266].

Facts

- The UK introduced the High Potential Individual Visa in May 2022, allowing recent graduates from elite global universities to enter the country without job offers, specifically to stimulate economic growth [267]. Subsequently, similar initiatives were adopted by the UAE, Canada, and Australia [268, 269, 270], collectively attracting over 300,000 specialists.
- In 2023, China and Italy implemented substantial tax incentives for expatriates, including tax-free allowances and up to 60% tax reductions, designed to attract high-skilled foreign talent and accelerate innovation [271, 272]. Building on this trend, in February 2025, Portugal introduced a tax incentive targeting a particular sector of scientific research and innovation [273].
- Since 2024, at least 12 new or updated visa programs have been introduced globally to attract founders, scientists, and entrepreneurs, including the UK Innovator Founder Visa [274], the New Zealand Entrepreneur Visa [275], and the Canadian Startup Visa program [276].

Key Drivers

- European companies struggle with widespread skill gaps, with nearly 60% unable to recruit needed ICT specialists [277]. By 2030, the EU expects shortages of 8M ICT [278] and 4M healthcare professionals [279]. Germany faces a particularly stark demographic challenge, with its working-age population projected to shrink by 9M by 2040 while its retirement-age population grows by 4M, leading policymakers to explore new solutions for skilled labor [280, 281].
- High-skilled immigrants drive innovation globally, founding 63% of US unicorns [282], 45% of Fortune 500 companies [283, 284], and 21% of German startups [285]. They produce 52% of US STEM doctorates [264] and 22.5% of new patents in Germany's IT sector [286].

Challenges

- A rising public sentiment against immigration makes special visa programs more challenging, with high-skilled immigration remaining politically sensitive [287].
- Around 70% of workers relocate to English-speaking countries such as the US, UK, and Singapore, suggesting that language barriers present a significant challenge for non-English-speaking countries in attracting global talent [288].

Impact on the Future of Policy-Enabled Innovation

Immigration policies that attract skilled individuals have the potential to strengthen economies by closing talent gaps and fostering innovation [289]. As a result, many countries are designing streamlined immigration frameworks and adopting more open visa policies to bring in professionals and entrepreneurs, fueling a dynamic and competitive economy [290]. To stay ahead, however, these policies must be continuously refined to meet evolving needs and create environments where both local and international talent can thrive [291, 292].

ECONOMIC TRENDS

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

AI-Driven Business Model Transformation
Uprising Regulations Hamper SMEs
Workforce Disruption Through AI Agents
European Military Build-Up
Healthcare - A Focus on Prevention

Elena Herzog 
Joël Hainzl 
Jorge Vincentelli 
Lena Ehrenreich 
Max Rosenblattl 

ECONOMIC TRENDS

Influencing the Future of Policy-Enabled Innovation

The global economic landscape is rapidly transforming, shaped by technological advancements, geopolitical shifts, and regulatory pressures. AI redefines workforce dynamics and business models, offering efficiency gains while disrupting traditional structures. Automation is accelerating a shift toward outcome-based pricing and AI-as-a-Service models, forcing businesses to rethink value creation. Companies like Zendesk exemplify this trend by charging customers based on successful results delivered by AI agents rather than per-user fees [293]. The widespread adoption of automation presents challenges ranging from job displacement to regulatory oversight, especially in sectors like financial services and healthcare [294, 295].

Geopolitical tensions, exemplified by Russia's aggression in Ukraine and shifting American security commitments, have triggered Europe's largest military buildup in decades. Germany's 100B EUR defense fund extension [296] and the EU's 800B EUR ReArm Europe Plan signal a push to strengthen domestic industries and enhance strategic autonomy [297, 298]. Moreover, directed toward domestic R&D, these funds have the potential to stimulate economic growth, but institutional inefficiencies in fragmented defense markets may hinder cost-effective innovation and interoperability. As Europe's automotive sector faces declining global competitiveness, the defense industry presents an opportunity to absorb skilled labor and manufacturing capacity, sustaining industrial output [299].

At the same time, healthcare systems face pressures from aging populations, rising costs, and workforce shortages. Governments are shifting toward preventive models, leveraging digital health solutions like predictive analytics and telemedicine to improve efficiency and patient outcomes. Despite a predicted healthcare spending at 12% of GDP in 2025 [300], Germany struggles with systemic inefficiencies, prompting reforms like the Digital Act [301]. Policymakers around the world increasingly prioritize proactive health measures and the integration of digital infrastructure to alleviate long-term strain on healthcare systems [302].

AI's impact, military rearmament, and preventive healthcare highlight the importance of policy in shaping economic outcomes. When aligned with technological and financial realities, policy can drive innovation, long-term prosperity, and resilience while mitigating disruptions. However, even when well-intended, excessive regulations can create unintended barriers, particularly for SMEs, which form the backbone of the EU economy. The rapid expansion of legislative requirements in recent years has placed disproportionate compliance burdens on smaller enterprises, diverting resources from innovation and growth. Rising administrative costs threaten their competitiveness, pushing some to consider relocation to more business-friendly regions. As governments navigate the complex balance between fostering innovation, maintaining security, and ensuring economic stability, they must recognize that overregulation can stifle the progress policies aim to achieve [303].

AI-DRIVEN BUSINESS MODEL TRANS-FORMATION

Revolutionizing Business Models with AI: Creation, Improvement, and Disruption

Artificial Intelligence fundamentally transforms traditional business models, particularly in the software industry. We can see companies like Zendesk [293], Intercom, and Agentforce by Salesforce challenging conventional business models by increasingly moving away from seat-based to more outcome-based pricing models [304]. In this model, customers don't pay usage or access fees but for delivered results or successfully completed tasks. AI doesn't replace SaaS but transforms its capabilities. One example of this is real time personalization and hyper-personalization [305] at scale through analyzing consumer data to create tailored experiences and recommendations as well as predictive insights [306, 307]. This improves user engagement and enhances accessibility for underrepresented groups through automated translations, adaptive user interfaces, and simplified workflows that cater to varying abilities [308, 309]. On top of that, federated learning and other AI technologies are fundamentally transforming business models by enabling decentralized data processing and therefore reducing breach risks, enabling cross-organizational collaboration, and compliance with existing regulations like the GDPR [310].

Facts

- Outcome-based pricing has gained market traction over the last few years [311].
- AI-driven technologies like chatbots, virtual assistants, and machine learning are enhancing user experiences in SaaS through personalized interactions [312, 313].
- AI unlocks new revenue streams and business models by analyzing customer data and market trends [314]. While it may displace some jobs, it will also generate new roles and business opportunities [315, 316, 317, 318].
- AI-enabled firms show 12.5% revenue growth compared to 7.3% for non-AI firms [319].

Key Drivers

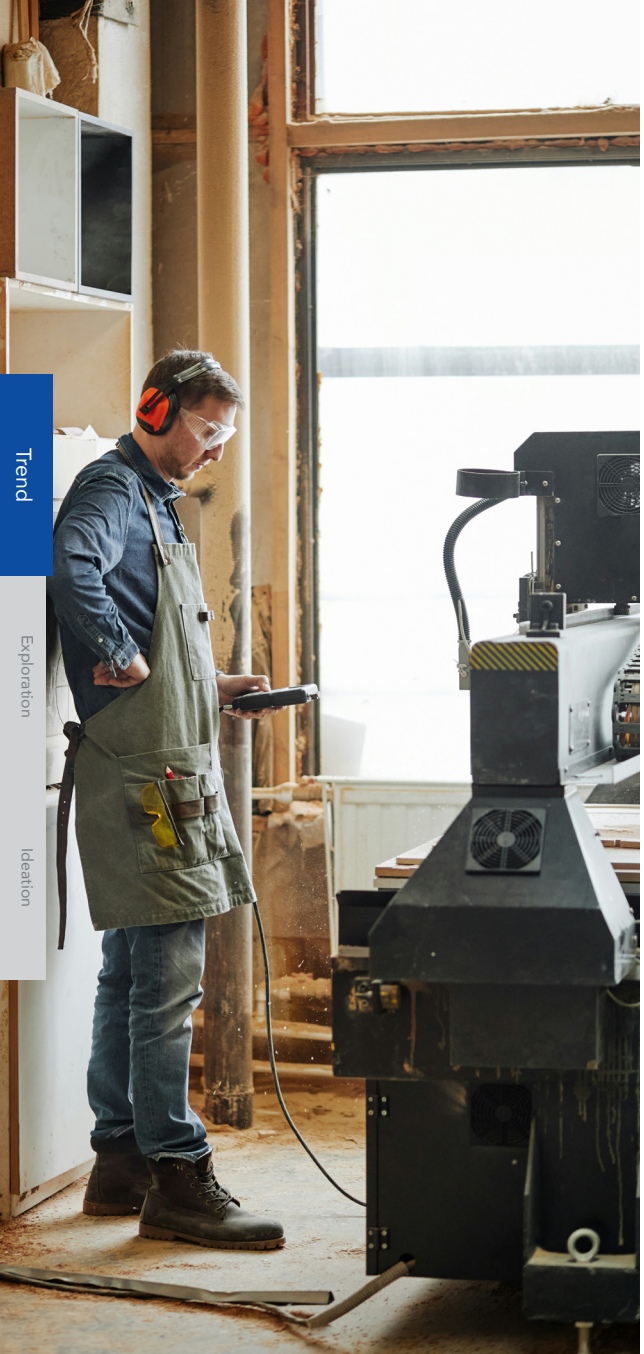
- AI reduces costs [320], giving companies strong incentives to adopt the technology. Furthermore, customers will most likely demand specific standards like personalization [321, 322], putting additional pressure on businesses to update their business models.
- McKinsey Global Institute is predicting an additional worldwide economic output of 13T USD by 2030 due to AI utilization [323]. In the face of global cost competition, businesses must adapt quickly or risk falling behind.

Challenges

- Success requires pilot projects, in-house AI teams, and broad AI training [324], all of which require skilled employees currently in short supply. This talent shortage drives up costs, making it particularly challenging for SMEs to fully leverage AI's potential.
- Ensuring responsible and ethical AI development and maintaining data privacy, security, and transparency [325], while driving innovation and maintaining operational efficiency [326].
- Over-reliance on AI can weaken creativity and decision-making, making it crucial to safeguard critical know-how and maintain human expertise [327, 328].

Impact on the Future of Policy-Enabled Innovation

AI is evolving rapidly, creating a demand for adaptive policies that can keep up with the speed, such as tax flexibility and continuously updated regulations. These policies must balance fostering innovation and ensuring global economic competitiveness, guaranteeing data privacy, security, and ethical AI use. Effective implementation can secure data as a valuable resource, drive cost savings, and generate additional funds that can be reinvested to further accelerate innovation.



UPRISING REGULATIONS HAMPER SMEs

Bureaucratic Barriers Stifle SMEs' Ability to Prioritize Innovation

European SMEs drive over half of the region's GDP and employ 66% of its workforce [329], yet rising regulatory burdens threaten their competitiveness [330]. In five years, the EU introduced 13,900 legislative acts, far exceeding the U.S.'s 3,700 [331], imposing high compliance costs that divert resources from innovation and growth [332]. Lacking the monetary resources or compliance departments of larger corporations, SMEs are disproportionately affected. Regulations often favor major industry players, neglecting niche sectors affecting SME operations [333]. This dual challenge of excessive regulation and talent migration risks is weakening Germany's innovation capacity and long-term economic resilience, particularly in vulnerable regions [334]. SMEs are the backbone of the European economy, and to sustain a dynamic business environment, policymakers must balance regulatory goals with SME-friendly frameworks that promote growth, agility, and inclusive innovation.

Facts

- Regulation is seen as a major hurdle by 60% of EU companies, with 55% of SMEs naming regulatory burdens as their biggest challenge [335].
- Germany is facing a sharp rise in bureaucratic hurdles as administrative costs soar by 9.3B EUR, reaching 26.8B EUR, representing a 54% rise compared to the previous year [303].
- 70% of German industrial firms see excessive bureaucracy as a significant challenge, prompting nearly half to explore expansion abroad and therefore hindering intra-European innovation [336].

Key Drivers

- The EU leads globally by focusing on sustainability goals through initiatives like the EU Green Deal, CSRD, and CBAM. These regulations address climate change, support SDGs, and set high international standards [337].
- Data protection ambitions have driven the EU to expand GDPR. This strengthens privacy safeguards amid rapid digital growth [338].
- Regulations protecting public health resulted in the REACH directive. Continued expansion of PFA restrictions further ensures inhabitant safety [339].

Challenges

- Complex regulations can be an advantage to large companies that have the resources to deal with them effectively, incentivizing them to lobby against changes that level the playing field for SMEs [340].
- SMEs face regulatory uncertainty and distrust after years of frequent legislative changes, making them hesitant to invest in new strategies even when simplifications are introduced [341].
- Designing simplification efforts for SMEs without weakening EU goals, including sustainability, data protection, or public health standards, remains a significant challenge [342].

Impact on the Future of Policy-Enabled Innovation

Increasing regulatory pressures compel SMEs to prioritize compliance at the expense of innovation and R&D, creating a restrictive atmosphere that stifles creative progress. The resulting brain drain accelerates as talent migrates to business-friendly regions like Singapore, leaving innovation gaps, especially in economically vulnerable areas. This shift undermines EU innovation strategies like Smart Specialization Community of Practice (S3 CoP) [343], as companies grow more risk-averse and prioritize compliance over innovation.

Moreover, regulatory uncertainty discourages high-skilled workers from remaining in the EU, limiting career opportunities in over-regulated sectors. Without a more balanced framework, excessive bureaucracy will continue to stifle SME-driven innovation and erode the EU's economic resilience [344]. Policymakers must streamline regulations, enhance clarity, and ensure SME-friendly policies to sustain Europe's innovation capacity and retain its entrepreneurial talent and financial resilience [332].

WORKFORCE DISRUPTION THROUGH AI AGENTS

Reshaping the Workforce: Efficiency Gains and Job Disruptions

Generative AI enables the autonomous creation of original content, including text, images, video, audio, and code. Foundation models serve as the backbone for generative tasks, with LLMs being the most prevalent type used to enable agentic systems [345]. These systems can be classified as agents or workflows. An agent is a fully autonomous system working independently that dynamically directs its processes and tool usage. Workflows, on the other hand, are prescriptive implementations following predefined code paths [346]. This technology could enhance the performance of skilled workers, improving their productivity by nearly 40% [347]. It could replace up to 15% of manufacturing, retail, and customer service jobs while automating 30-50% of financial services and healthcare tasks. Its increasing adoption is reshaping work, raising concerns about human skills and the future of work, making it essential for workers to adapt by developing unique capabilities [348]. As LLM capabilities continue to advance, their economic impact is expected to grow, presenting ongoing challenges for policymakers in forecasting and regulating their development [349].

Facts

- Since LLMs have emerged, about 80% of U.S. workers could see AI influence 10% of their tasks, while 19% might have over half of their tasks reshaped by automation, with higher-wage occupations generally showing greater exposure [349].
- AI automation is expected to boost GDP over the next decade. However, the expected increase ranges from 1% to 7%. Similarly, productivity growth is expected to rise between 0.66% and 1.5% [350, 320].
- The UK central government is responsible for about 36% of all transactions, and 84% are highly automatable. By reducing the time spent on each of these transactions by just one minute, it could save the equivalent of 1,200 person-years of work annually [351].

Key Drivers

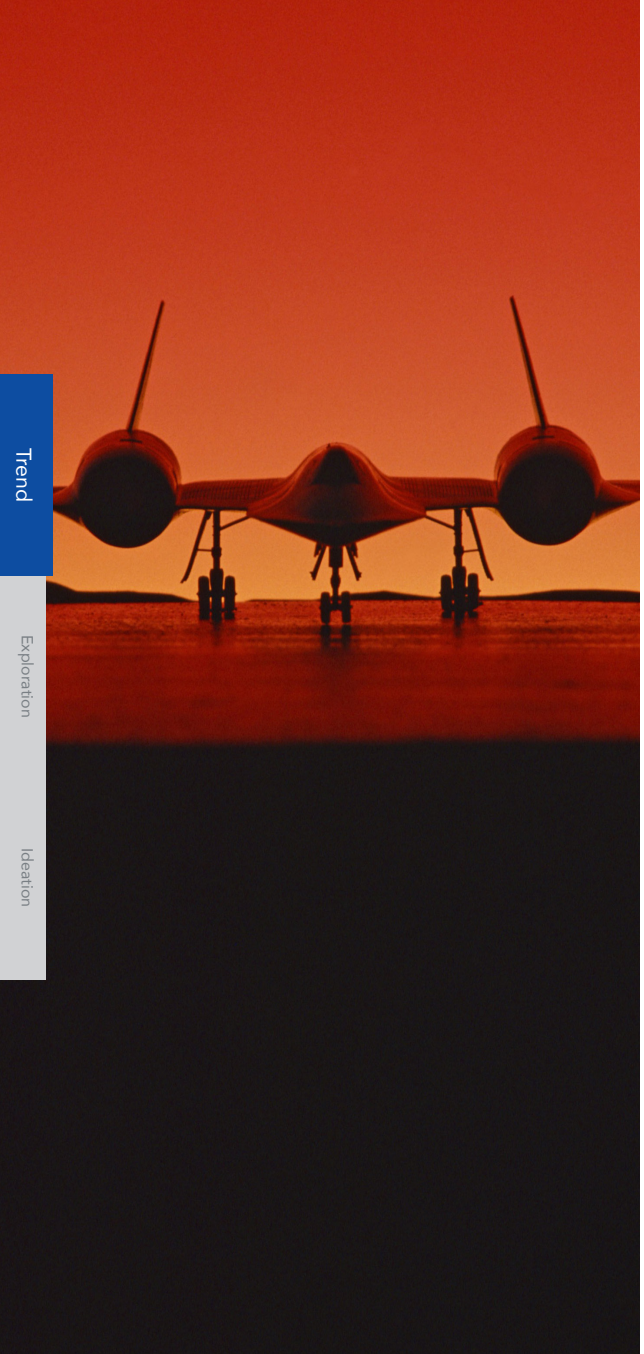
- The AI sector reached a record-high investment of 110B USD in 2024, with Generative AI companies securing 47.4B USD [352].
- AI systems are now able to reason independently and evaluate their decisions. If AI agents are considered part of the workforce, this could potentially double the digital workforce, with AI agents autonomously managing tasks [353].
- Demographic shifts, especially aging populations, are driving the adoption of robots and automation technologies. This adoption is particularly evident in industrial sectors, where it leads to increased productivity [354].

Challenges

- While creating new roles, millions of jobs are expected to be displaced, with up to 300M full-time jobs impacted by automation [355].
- Cost-effectively implementing AI automation presents significant challenges for small firms, as they often lack the financial resources, technical expertise, and infrastructure required to support such advanced technologies [356].
- Although 36% of U.S. non-farm jobs involve at least one task suited for computer vision, only 23% of those have tasks that are cost-effective for firms to automate [357]. Despite phased deadlines, the EU AI Act's timeline poses challenges as many organizations struggle to interpret its ambiguous legal requirements and turn them into practical compliance [358].

Impact on the Future of Policy-Enabled Innovation

Investment in AI is at an all-time high [352], but its productivity impact is less significant than anticipated [350]. Additionally, regulations like the EU AI Act challenge companies aiming to accelerate automation tools. Automation is a major opportunity to enhance productivity in the public sector. Still, without national-scale implementation, high upfront costs may make it impractical for individual SMEs to adopt new technologies.



EUROPEAN MILITARY BUILD-UP

Unlocking Economic Opportunities through Europe's Strategic Defense Realignment

Russia's continued aggression and changing American commitment to European security fuels nations across the continent to dramatically increase military spending. Germany is a key example, with Chancellor-designate Friedrich Merz promising to do 'whatever it takes' for defense [359]. While Germany has already committed a sizable investment of 100B EUR in a special fund, Merz proposes to go further by bypassing debt brake restrictions [298, 359]. This momentum is also reflected on a continental scale. In March 2025, European Commission President Ursula von der Leyen unveiled the unprecedented 800B EUR 'ReArm Europe Plan' to enhance defense capabilities across the continent [297]. These historic investment commitments signal a pivotal moment. The impact of this spending surge on Europe's economy will depend on where these additional funds are directed. A clear focus on domestic defense production and innovation could not only enhance Europe's military autonomy but also spark a wave of technological breakthroughs and job creation [360, 299].

Facts

- The EU's military spending in 2024 is estimated at 326B EUR, a drastic increase from 214B EUR in 2021, with approximately 90% of the increased spending allocated to purchasing defense equipment [361].
- Between mid-2022 and mid-2023, nearly four-fifths of the EU's defense procurement spending went to non-EU suppliers [362].
- The car industry faces declining demand and foreign competition, prompting job cuts and plant closures. Rheinmetall, Europe's leading ammunition maker, is converting two automotive parts plants to produce defense equipment, while Hensoldt just took on 200 workers from auto suppliers Bosch and Continental [299].

Key Drivers

- The United States is actively pushing the EU to take greater responsibility for its security, with top American leaders consistently emphasizing a strong desire to avoid relationships of strategic dependency [363].
- Russia's ongoing aggression in Ukraine has forced Europe to rethink its security posture. Policymakers fear that Russia might leverage its gains to pursue territorial or political dominance in other vulnerable European areas [364].
- Hybrid warfare, combining conventional and unconventional tactics, is an escalating threat. Attacks on critical infrastructure, including subsea cable sabotage, cyberattacks, and disinformation campaigns, are becoming more frequent and sophisticated [365].

Challenges

- The fragmented European defense market and lack of common standards drive up costs. National preferences lead to small-scale production, while limited interoperability complicates logistics and weakens combat effectiveness. EU countries, for example, have supplied Ukraine with ten different howitzer cannon types, whereas the US produces only one [362].
- The persistent negative stigma surrounding defense investments continues to restrict funding. This makes it especially difficult for small and mid-sized firms and start-ups to access the capital needed for innovation in critical areas such as drones [366].

Impact on the Future of Policy-Enabled Innovation

Policies should be set up to direct increased defense spending towards domestic research and development, fostering technological innovation. Investments in high-tech defense systems could lead to dual-use technologies with civilian applications, such as advancements in drones, AI, and cybersecurity. Historical examples, like the internet and GPS, show how military research drives broader technological breakthroughs [367]. By prioritizing defense innovation, Europe can boost economic growth, reduce reliance on external suppliers, and enhance global competitiveness.

HEALTHCARE - A FOCUS ON PREVENTION

Addressing Disease Before it Starts

Over the last few years, there has been a global shift toward prioritizing population health over treating diseases. This shift emphasizes the importance of prevention, health promotion, and proactive measures to reduce the overall burden of illness [368]. It holds the potential to significantly improve both health and the economy worldwide by leveraging new technologies like AI and digitized healthcare systems [302, 369]. While Germany's healthcare system is crucial to its economy and society, it is the most expensive in Europe without performing better by population health metrics [370]. Germany spends slightly more on preventive healthcare than the EU average, but prevention remains underemphasized [371]. System fragmentation causes a lack of comprehensiveness in the public health strategy, leading to limited use of preventive and population-based measures [372]. Addressing these issues could help alleviate recent economic weaknesses in Germany, with GDP declining by 0.2% in 2024 [373].

Facts

- Investing in preventive health boosts economic growth by reducing absenteeism, cutting healthcare costs, improving productivity, and easing pressure on public health systems [302].
- The global focus on preventive medicine has grown, with improvements in digital health, vaccination efforts, and healthcare infrastructure [368] along with more private sector investment in preventive medicine companies like Neko Health and Cera [374, 375].
- Germany spends the highest proportion of GDP on healthcare in the EU (12.9% in 2021, vs. 11.0% EU average), yet health outcomes remain average [376]. Avoidable hospital admissions cost eight times the OECD average [377].

Key Drivers

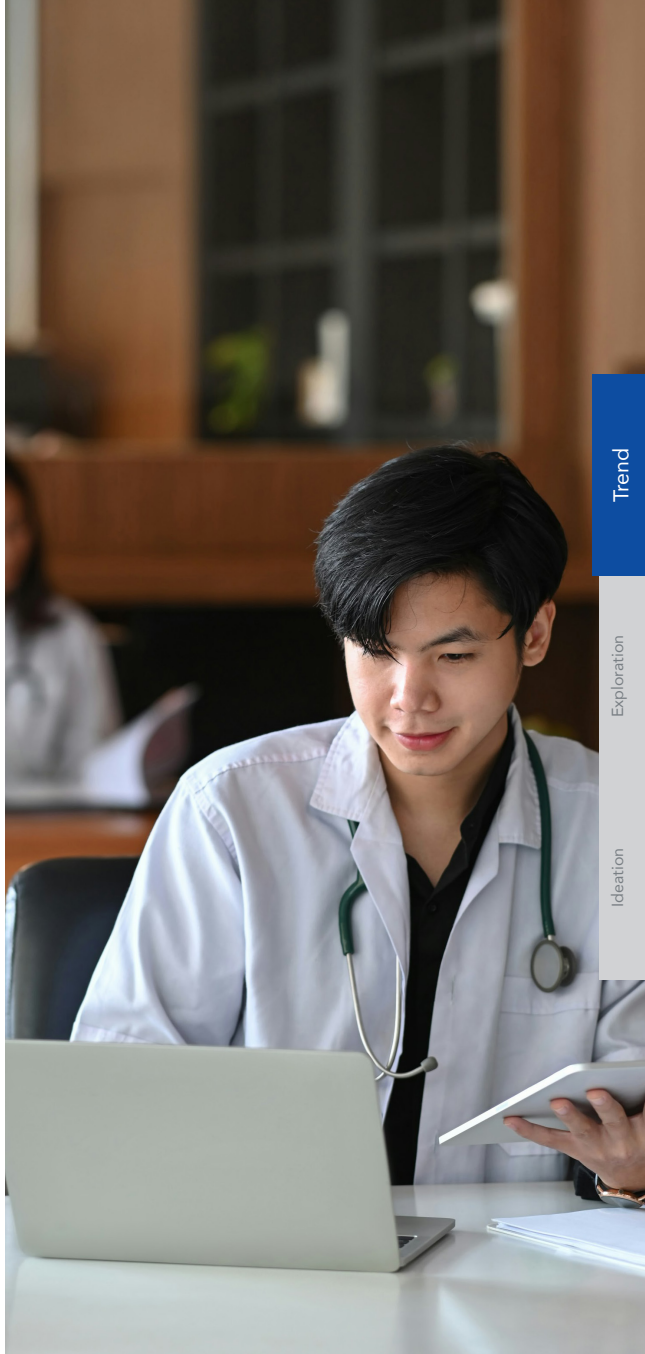
- Germany faces an aging population (22% are 65 or older), rising chronic diseases, a shrinking workforce, and growing healthcare costs, driving the need for system efficiency and preventative solutions [376].
- Technological advancements like AI and digitalization are transforming preventive healthcare with better diagnostics, virtual care, remote monitoring, patient engagement, and personalized prevention through data analytics [378].
- COVID-19 has accelerated the focus on preventive medicine globally by highlighting the importance of vaccines, early diagnosis, and chronic disease management while driving innovation in digital health technologies [379, 368].

Challenges

- Germany's healthcare system is highly fragmented [370], with disconnected data, scattered responsibilities, and poor sector coordination, resulting in ineffective public health strategies and limited use of evidence in prevention [372].
- Designed to focus on individualized treatments, the German healthcare system places less emphasis on prevention and social services due to a remuneration framework centered on disease treatment. This structure offers limited financial incentives for healthcare providers and the industry to prioritize preventive solutions [370].

Impact on the Future of Policy-Enabled Innovation

Economic incentives must be created to encourage providers to prioritize prevention over treatment to unlock the benefits of a prevention-focused healthcare system. At the same time, a centralized body needs to define and implement evidence-based public health policies and population-based measures. This will require changes to the healthcare remuneration system to align incentives with prevention. Additionally, reducing system fragmentation and focusing on digitization will be crucial, and these areas will likely need policy adjustments. Combining this with strong data security standards poses a challenge and the opportunity to promote a healthier society and less monetary burden on the state through well-placed policies.



ENVIRONMENTAL TRENDS

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

Smart and Flexible Energy Systems
Quality of Market-Based Instruments
Data-Driven Agriculture
Shift to Circular Resource Management
Future-Proofing Cities

Ece Özdağ 
Fynn Schäfer 
Ilda Karaj 
Paul Zeller 
Sven-Christian Hörner 

ENVIRONMENTAL TRENDS

Influencing the Future of Policy-Enabled Innovation

Climate change is one of our time's most pressing global challenges, profoundly disrupting ecosystems, economies, and societies [380]. Rising temperatures, extreme weather events, and biodiversity loss threaten global environmental and economic stability, causing projected annual damages of roughly 38T USD in 2050, accompanied by a projected income reduction of 19% [381]. These risks will escalate without decisive action, undermining economic security and threatening future generations' ability to thrive [382].

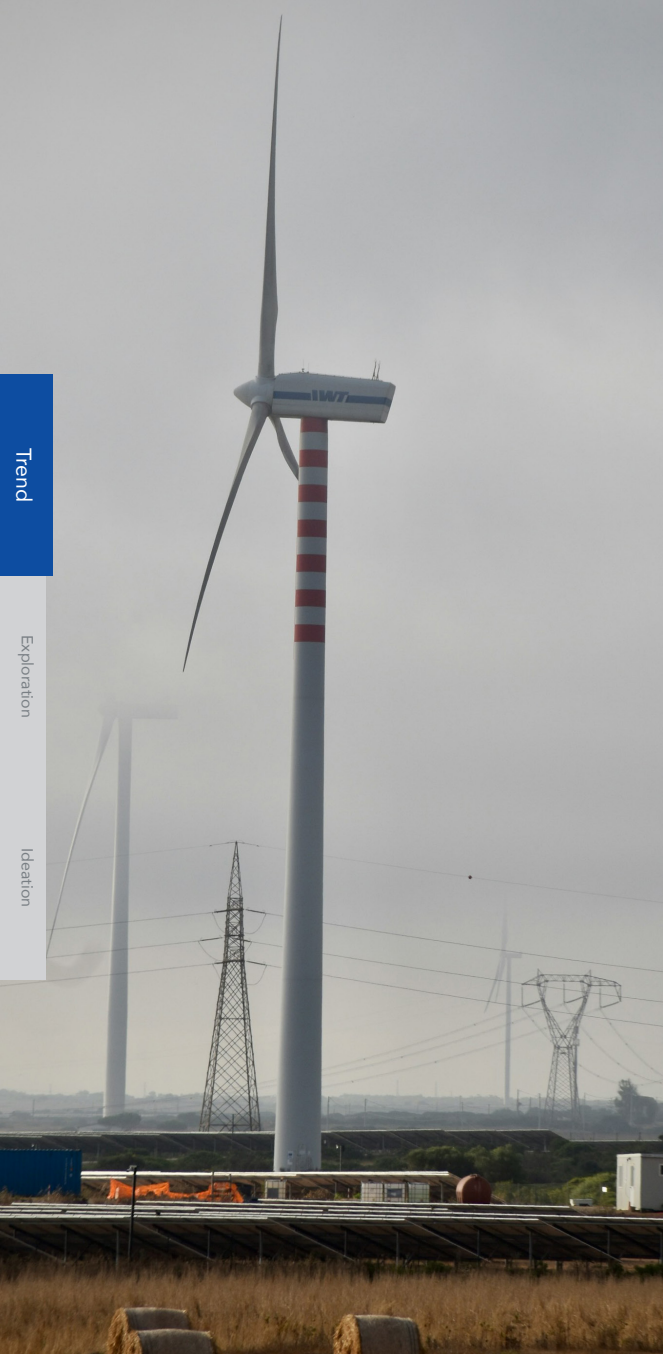
At its core, climate change represents a market failure: greenhouse gas (GHG) emissions, resource depletion, and ecosystem destruction are unpriced externalities, leading to unsustainable economic decision-making by private companies. Overcoming this failure requires robust institutional frameworks, targeted policies, and market instruments to correct the distortions. These measures will also enable technological breakthroughs and unlock investments for a sustainable future [383, 384]. Without these foundational elements, efforts to scale up adaptation and mitigation will remain fragmented and insufficient [385].

Traditional environmental policies have proven insufficient to address complex environmental challenges, requiring a shift from reactive to preventive and transformative approaches [386]. The key is developing comprehensive policy frameworks that combine innovation incentives with regulatory standards to achieve cost-effective decarbonization [387].

A well-designed policy environment provides regulatory clarity, giving businesses and investors the confidence to scale environmental solutions. Financial mobilization ensures capital flows efficiently toward sustainable projects and unlocks long-term economic growth [388]. Governments can facilitate private sector participation through policy instruments such as green bonds, carbon pricing, and climate risk insurance [389]. These measures help create stable conditions for investment in clean technologies, circular business models, and low-carbon industries. By strategically providing tailored funding mechanisms across R&D, early deployment, and large-scale adoption, governments can stimulate innovation, attract private investment, and drive sustainable economic growth [390].

Policy-driven technological advancements accelerate the deployment of clean energy technologies, resource-efficient systems, and climate adaptation solutions. Integrating digitalization through smart grid technologies, remote sensing, and digital product passports can enhance solutions' adaptability, precision, and impact, ensuring they remain responsive to evolving challenges. Policy-driven approaches show that climate innovation thrives through strategic policies, financial frameworks, and digital technologies, which enhance effectiveness and accelerate progress.

The following sections will explore five key policy-enabled innovation trends driving the transition toward a more sustainable and resilient environment. These trends include smarter energy systems, data-driven solutions, circular resource management, climate-adaptive urban planning, and the deployment of market-based instruments. By examining these trends, society can better understand how governments can leverage regulation, incentives, and innovative technologies to drive climate resilience and economic transformation.



SMART AND FLEXIBLE ENERGY SYSTEMS

Paving the Way Toward a Digital, Resilient, and Sustainable Energy Future

Smart and flexible energy systems are a cornerstone of the global energy transition, driven by the rapid growth of variable renewable energy (VRE) sources, the growing electrification of heating, mobility, and industry, and the coinciding need for enhanced grid resilience. In 2023, the capacity of renewable power increased by 473 gigawatts (GW) globally [391]. The unprecedented growth in renewable energy capacity underscores the urgency of developing more flexible and intelligent energy systems, encompassing, among others, the digitalization of energy infrastructure and the evolution of market structures to accommodate new forms of energy generation and consumption. A failure to implement integration measures for solar and wind capacity could jeopardize up to 15% of VRE generation in 2030, highlighting the critical need for flexible solutions [392]. To facilitate a sustainable energy future, continued progress in investment, regulatory adaptation, and resilient digital and physical infrastructure will be essential [393].

Facts

- In 2022, the European Union (EU) launched "Digitalizing the Energy System," an action plan to promote connectivity and interoperability. The plan also supports investments in smart grid technologies and reinforces governance structures to accelerate digital innovation [394].
- Building operations are responsible for 35% of GHG emissions in the EU and are undergoing rapid decarbonization through renewable heating systems, such as heat pumps powered by renewables, and energy efficiency measures [395].
- By 2040, Bavaria will need 30 GW of electrical flexibility to balance volatile renewable generation [396].
- Demand response will account for 500 GW by 2030, representing 20% of flexibility in developed economies [397].

Key Drivers

- The growing share of VRE generation requires greater system flexibility across the value chain, including demand response, batteries, and low-carbon flexible power [398, 399].
- Growing demand for electricity from industry, EVs, and heat pumps will significantly increase demand for flexibility [400, 401].
- The rollout of IoT devices, dynamic pricing, and digital technologies for energy management, forecasting, and optimization is setting consumers up for more advanced energy use cases, with Europe set to reach 272M smart meters by 2030 [397].
- In Germany, changes to the Energy Industry Act are introducing variable grid fees, incentivizing demand response [402].

Challenges

- Investment rates into transmission and distribution grids need to increase by 2-3x to 75-100B EUR annually until 2050 [403].
- As energy systems become interconnected, cyber risks and data privacy concerns grow [394].
- Market incentives for demand response remain insufficient due to outdated grid fee structures and the slow rollout of smart meters in Germany. The lack of clear legal frameworks and high entry barriers to balancing markets are constraining demand response [404, 397, 405].
- Lengthy approval processes and poor data availability delay critical grid infrastructure and slow the energy transition [406].

Impact on the Future of Policy-Enabled Innovation

Governments can drive innovation by shaping digital infrastructure, regulations, and market conditions. Investments in smart grids and AI-driven applications enhance energy efficiency, while data interoperability and cybersecurity enable seamless market integration [394]. Regulatory sandboxes and research programs support emerging technologies like green hydrogen and generative AI, fostering innovations [407, 408]. Furthermore, strengthening market incentives for demand response boosts flexibility and can support heating decarbonization by integrating renewables and optimizing consumption [409, 395].

QUALITY OF MARKET-BASED INSTRUMENTS

Driving Effective and Transparent Environmental Markets

Market-based instruments (MBIs) utilize markets to internalize environmental externalities. These instruments direct capital toward emissions reduction, renewable energy development, and other environmental activities. Key examples are carbon markets, which cap emissions and allow trading, and energy attribute certificates (EACs), which certify the green origin of electricity. Covering over 40% of EU emissions, the EU Emissions Trading System (ETS) is the world's largest carbon market [410]. MBIs are essential for achieving net-zero goals efficiently [411]. As MBIs expand across sectors and voluntary markets gain traction, the focus is shifting toward stricter verification, real-time tracking, and sector-specific adaptability to ensure credibility, prevent greenwashing, and enhance market efficiency.

Facts

- In 2023, 73 carbon pricing instruments covered 23% of global GHG emissions, up from just 7% ten years prior [412].
- On average, carbon markets reduce GHG emissions by 12.1%, outperforming carbon taxes [413].
- The use of voluntary MBIs, such as carbon and biodiversity credits, is growing yet remains highly volatile, with carbon credit retirements stagnating and prices dropping ~20% in 2023 after a period of rapid growth [414].
- EACs have become ubiquitous, with the issuance volume of certificates representing 90% of total renewable energy production [415].

Key Drivers

- Markets for voluntary and compliance MBIs are converging, with Article 6 of the Paris Agreement facilitating government-backed credits in voluntary markets (e.g., CDM/PACM), increasing the quality and credibility of voluntary markets [416].
- Stricter verification frameworks such as the Voluntary Carbon Markets Integrity Initiative and Council for the Voluntary Carbon Market are driving markets toward higher-integrity MBIs [412].
- The adoption of digital technologies enhances real time traceability and credibility, as seen in initiatives like EnergyTag, which set standards for granular energy certificates [417].
- EU ETS is expanding to buildings, transport, and other sectors, strengthening MBIs as an emissions reduction tool [418].

Challenges

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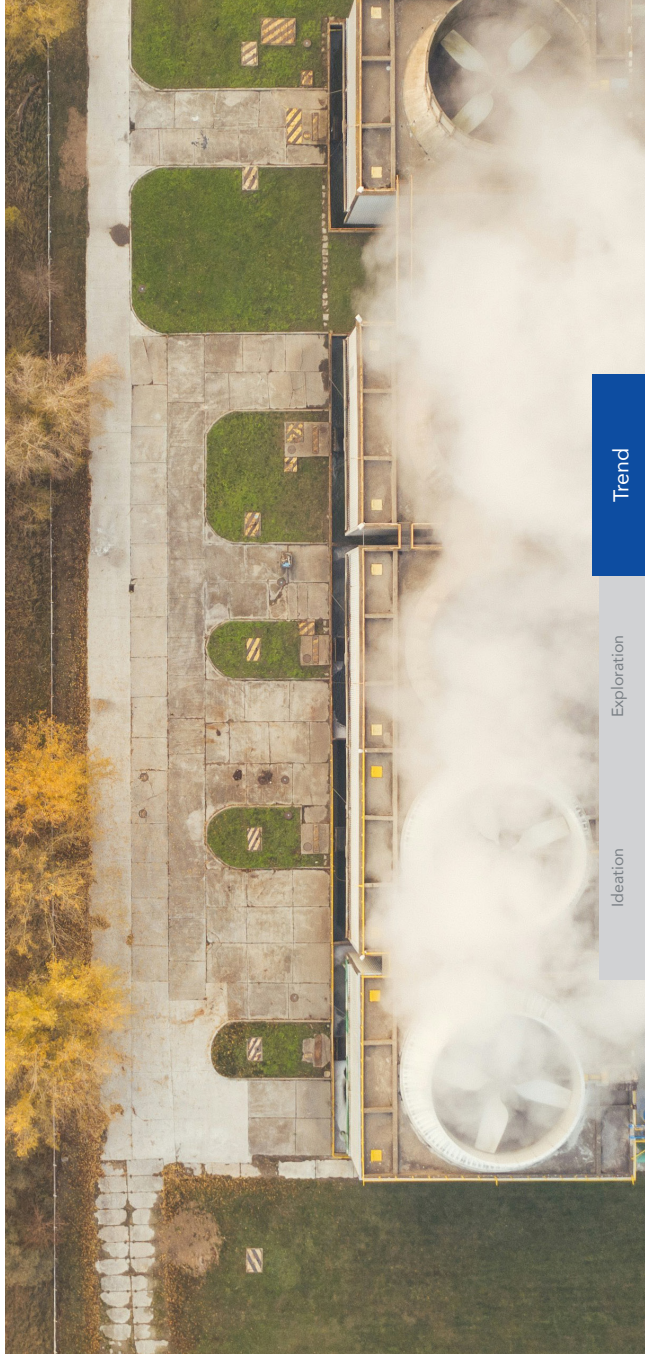
Impact on the Future of Policy-Enabled Innovation

MBIs drive policy-enabled innovation by creating financial incentives for clean technologies. For example, carbon pricing mechanisms lower emissions while maintaining economic performance [411]. However, market distortions, such as low certificate prices caused by oversupply or weak standards, can undermine the effectiveness of such markets [416, 422]. Investment signals weaken when prices fail to reflect actual environmental value, slowing technological progress. Strengthening MBIs' quality through strict verification, transparency, and integrity requirements ensures environmental markets drive innovation while preventing greenwashing and maintaining investor confidence [416].



DATA-DRIVEN AGRICULTURE

Leveraging Digital Solutions for Agricultural Productivity and Sustainability

Bavaria has the largest agricultural land area and organic farming industry in Germany [426]. With productivity and profitability threatened by climate change and rising input costs, farmers must adopt new solutions, innovating beyond conventional agricultural practices. Simultaneously, they face increasing regulatory demands, such as the EU´s Farm to Fork Strategy, which aims to achieve a 50% reduction in nutrient loss across all member states by 2030 [427]. Additionally, farmers must implement standardized measurement systems to provide verifiable evidence of meeting sustainability requirements. The dual pressures of improving productivity and stricter regulations have been major drivers for adopting precision agriculture (PA) practices among Bavarian farmers. PA refers to farming approaches that use technology and data to improve efficiency, sustainability, and decision-making, with applications, particularly in resource management and yield optimization [428]. Falling sensor costs in recent years have accelerated this shift, enabling more data collection for new machine learning (ML) applications in PA [429].

Facts

- In 2024, the EU's Soil Monitoring Law entered final negotiations to establish a harmonized soil health framework. It will require European farmers to follow standardized assessment measures and provide incentives such as Soil Health Certificates [430].
- Only 9–12% of farmers currently use advanced sensing technologies like drones and satellite-based remote sensing in daily operations [431].
- From 2020-2024, Germany lost more than 2,600 farms annually on average – driven in part by falling prices and stricter environmental regulations, alongside other structural pressures [432].
- Larger German farms (+99 hectares) are nearly twice as likely as smaller ones (20-49 hectares) to invest in ML-powered PA (52% vs. 27%) [433].

Key Drivers

- With profit margins under pressure from fluctuating marketing prices, rising energy costs, and weather volatility, Bavarian farmers face a growing need to increase farming productivity [434].
- The EU Farm to Fork Strategy enforces comprehensive data collection standards for farmers. Bavaria's large organic farming sector faces even stricter certification rules, increasing the need for more sensing technologies [435].
- The expansion of IoT sensors increases data availability, enhances ML training, and improves prediction accuracy across various PA applications [436].

Challenges

- The lack of data standardization significantly hinders the adoption of PA, as incompatible sensor formats prevent seamless integration and cross-platform analysis [437].
- High upfront investment costs and limited digital skills are the most critical barriers to PA adoption in small German farms [438].
- Two in three German farms in rural areas struggle with unreliable network infrastructure, disrupting real time data transfer and integration of PA applications [439].

Impact on the Future of Policy-Enabled Innovation

Bavarian farmers face growing pressure to enhance productivity due to climate variability, rising input costs, and strict environmental regulations. Thus, adopting data-driven agricultural practices becomes crucial for improving resource efficiency and traceability. Many farms, especially small ones, may fail to meet these evolving demands without support. State policies can help bridge this gap by providing subsidies or educational programs to enhance farmers' digital skills. Beyond direct aid, improving digital infrastructure can indirectly promote adoption, particularly in rural areas. Bavaria could take the lead in data standardization and promote open data sharing among farmers and public stakeholders to enhance integration.

SHIFT TO CIRCULAR RESOURCE MANAGEMENT

Advancing Circular Practices in Waste Management and Resource Utilization

The linear economy model of "take, make, dispose" has created serious environmental challenges, threatening ecosystems, pressuring essential resources [440] and posing risks to economic stability. To confront these impacts, society must transform how it consumes natural resources. Circular economy emerges as an imperative, embedding waste reduction, material reuse, and closed-loop systems into public and private strategies. This transition could reduce the EU's material consumption by 32% by 2030 [441], reducing dependence on raw materials and fostering economic and technological innovation [442]. Although there is EU-wide political agreement to take action [443], efforts to transition to circular approaches face challenges due to regulatory frameworks undermining rather than enabling circularity [444, 445].

Facts

- Global material consumption will double in the next 40 years [446], with waste generation increasing by 70% by 2050 [447].
- In 2022, Europe had the highest circularity rate in the world at 11.5% [447]. However, this level is still too low to stay within critical planetary boundaries, such as those for nitrogen, phosphorus, and land use which are the ones that can directly affect human life [448].
- Munich can reduce material consumption by 43% as well as cut consumption-based CO_2 emissions by 23% through circular economy interventions in areas like construction, food, and transportation [449].

Key Drivers

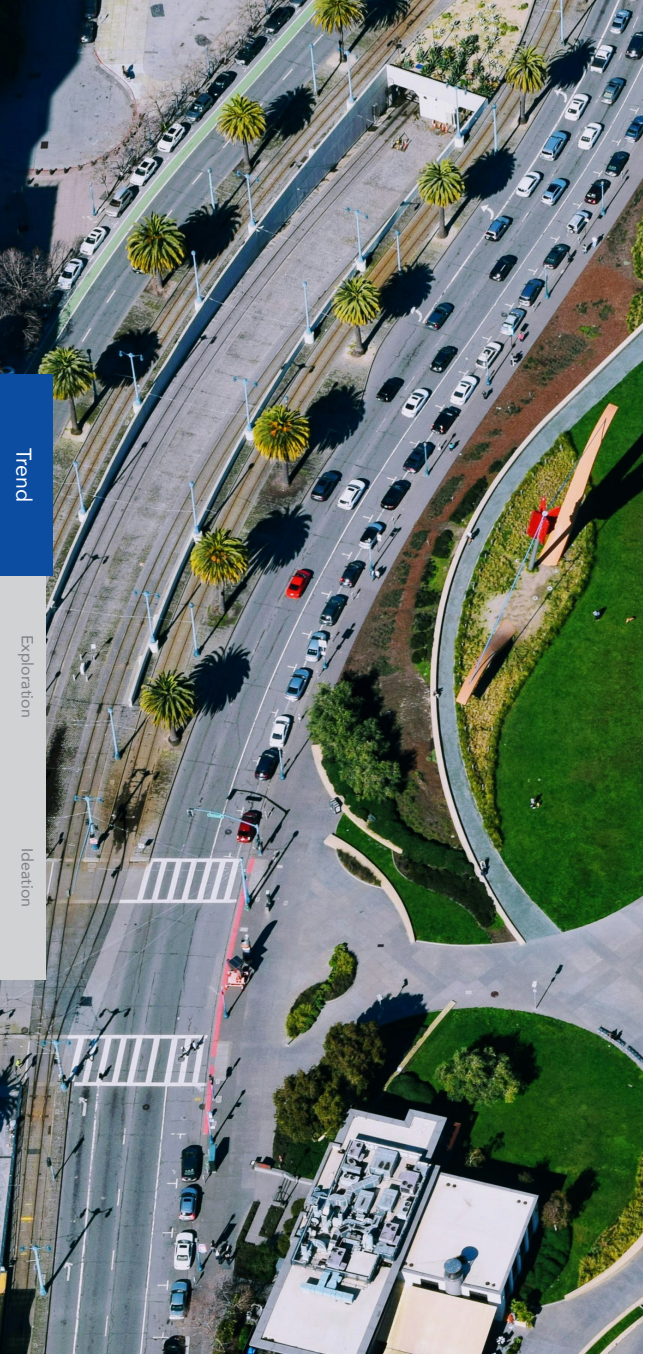
- Supply chain constraints have exposed Europe's resource dependencies, especially for critical raw materials [440].
- The EU's Circular Economy Action Plan and Ecodesign for Sustainable Products Regulation demand recycled content quotas, aim to double the circularity rate of materials, and establish digital product passports (DPP), which create material visibility by linking physical products to digital profiles with lifecycle data [450, 451, 452].
- Companies are leveraging low carbon materials certified by lifecycle assessments like Environmental Product Declarations (EPD) to attract customers, earn green premiums, and ensure products with a low CO_2 footprint [453].
- Innovations in waste valorization technologies [454], industrial symbiosis such as power plants sharing their by-products [455], and digital enablement of smart maintenance, repair, reuse, or remanufacturing enable efficient circular practice [456].

Challenges

- Transitioning to a circular economy requires big upfront investments in new technologies, while economic returns materialize much later. This creates a technology lock-in and impedes the adoption of circular techniques [457].
- EPD requirements vary between EU member states, with different methodological approaches, data requirements, and verification protocols [458].
- Legislation blocks viable secondary materials markets with restrictions on the recycling of viable products (e.g., biochar restrictions) or lack of enforced transparency of information necessary for recycling, such as material composition [459, 460, 461].

Impact on the Future of Policy-Enabled Innovation

A shift towards a circular economy requires targeted policies that drive technological innovation and create market incentives [462]. Smart legislation can break barriers to circularity, unlock investment, and push businesses toward resource efficiency and recycling. Bavaria's strong technological foundation positions it to invest in DPPs and lifecycle tracking systems that ensure transparency and material traceability. Policymakers can accelerate circular adoption by fixing regulatory inconsistencies, improving EU market conditions, and developing solutions like DPP platforms for more transparency, reducing material consumption, resource dependencies, and lowering greenhouse gas emissions.



FUTURE-PROOFING CITIES

Building Climate-Resilient and Adaptive City Ecosystems

Countries and cities worldwide are confronted with the impacts of climate change, including rising temperatures, severe storms, and flooding. By 2050, Germany could see a 466% increase in people exposed to flood risks and an 80% rise in heatwave occurrences [463]. Urban areas will be especially vulnerable due to dense populations, heat retention, and poor drainage [464]. To address these challenges, cities are adopting diverse strategies for climate resilience through a combination of infrastructure upgrades, nature-based solutions, and data-driven warning systems [465]. Examples include Malmö's rain gardens for stormwater drainage [466], Barcelona's digitally monitored stormwater tanks [467], and the EXTREMA tool in Athens, Paris, and Rotterdam for real time heat monitoring [467]. These initiatives illustrate that resilient urban ecosystems through innovative solutions not only mitigate environmental risks but also enhance public health and economic stability by reducing heat stress and flood damage [466].

Facts

- Between 1980-2021, extreme weather and climate-related events led to total losses of 560B EUR across the EU [464].
- Approximately 62% of cities worldwide report that climate hazards are directly linked to serious public health challenges [380].
- GeodataService Munich integrated the PALM-4U urban climate model with a Digital Twin of the city to simulate the city center's climate dynamics [468].

Key Drivers

- Growing climate challenges force cities to move beyond isolated infrastructure projects toward comprehensive, long-term adaptation strategies [469].
- The EU's biodiversity strategy for 2030 incentivizes cities to embed green infrastructure and nature-based solutions into urban development [470].
- Strategies and frameworks such as the Climate Adaptation Strategy and the Climate Adaptation Act motivate German cities to implement green and blue adaptation measures at all levels of decision-making [471, 472].

Challenges

- The lack of standardized evaluation methods makes it difficult to measure the effectiveness of climate adaptation and mitigation strategies in city planning [473].
- Scaling pilot projects across a city's broader infrastructure poses a major challenge for planners due to the need to weigh immediate costs against benefits that are uncertain and may only emerge over the long term [474].
- The effectiveness of digital solutions and technology-led innovations depends on access to data from a wide variety of sources, raising questions on data ownership, privacy, storage, and security of data [475].

Impact on the Future of Policy-Enabled Innovation

Climate change is placing unprecedented strain on urban environments, demanding more robust and integrated solutions [476]. Meanwhile, policies such as the Biodiversity Strategy 2030, Climate Adaptation Strategy, and Climate Adaptation Act not only impose new regulations on Bavarian cities but also offer strategic guidance and resources incentivizing innovative approaches in climate adaptation measures [477]. By combining digital technologies with nature-based solutions, cities evolve from isolated projects to smart, adaptive infrastructure systems that directly address climate impacts. With proactive policies, engaged citizens, and collaboration between urban areas, cities can overcome current economic and infrastructure challenges, ensuring a sustainable, resilient future in the face of climate risks [478].

EXPLORATION

In the upcoming chapter, the outcomes of the process for validating hypotheses and problem statements are explored. This phase primarily revolves around the discovery of white spaces and opportunity areas relevant for *The Future of Policy-Enabled Innovation*. By clustering the topic, findings are distilled into five key opportunity spaces, and the most critical problems and opportunities within the chosen domain are identified. The exploration phase places a priority on the testing and re-evaluation of hypotheses with expert insights, alongside an examination of the existing landscape to pinpoint selected players.


INNOVATION ECOSYSTEM
INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION
Commercializing Leading Research
Closing the SME-Innovation Gap
Reversing the Startup Drain

Jakob Mayer 
Maaz Ahmed 
Mara Jean-Krupa 
Max Rosenblattl 
Sven-Christian Hörner 

INNOVATION ECOSYSTEM

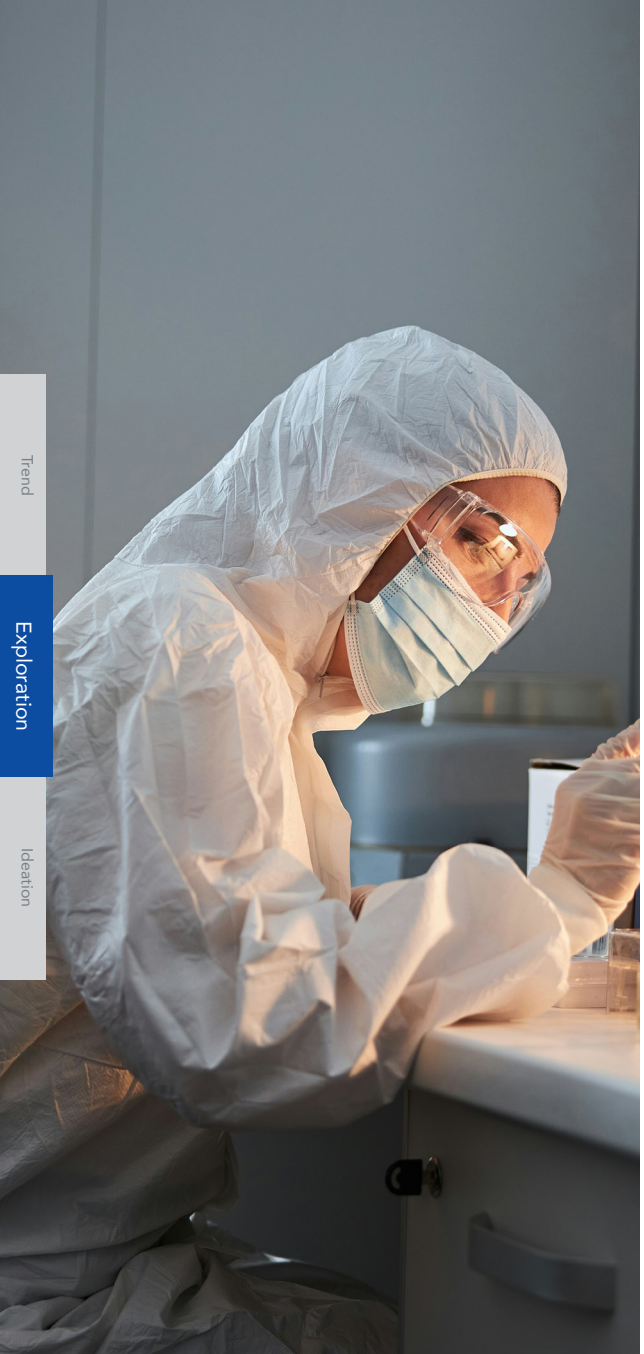
Laying the Groundwork for Germany's Future Competitiveness

Innovation has long been central to Germany's economic strength. With a globally respected research landscape, strong industrial R&D, and a reputation for engineering excellence, the country consistently ranks among the world's top innovation performers [479]. However, while Germany's innovation capacity remains high, there is growing concern that its ability to translate knowledge into entrepreneurial momentum is falling behind. Startups and small and medium-sized enterprises (SMEs), two key actors with the potential to turn R&D into broad-based innovations, face persistent challenges.

Founders often face a complex environment marked by administrative hurdles, slow processes, and limited access to growth capital [480, 481]. These structural issues have led many high-potential ventures, especially in technology fields, to relocate to more agile ecosystems abroad [481]. Meanwhile, Germany's efforts to attract international entrepreneurial talent remain limited in scale and scope, often fragmented across local programs without clear pathways or comprehensive support. At the same time, SMEs, the bedrock of Germany's economic model, are facing a steady decline in their innovativeness. While large corporations continue to invest heavily in R&D, many SMEs struggle with digital transformation, bureaucracy, and talent shortages [482, 483].

Capital markets and the institutional frameworks that support research commercialization present another bottleneck. Despite Germany's strengths in fundamental research, the funding needed to bring these technologies to market, especially at later stages, remains limited [484]. Institutional investors such as pension funds play no significant role in venture capital, in contrast to more mature ecosystems where they serve as a backbone of innovation finance [484]. Deep Tech companies initially require significantly more time and VC funding than regular tech [485]. This gap underscores a key contradiction: While Germany excels in producing breakthrough research, it lacks the domestic capital infrastructure to scale those innovations commercially. There are programs like SPRIN-D that are trying to fill this gap, but they fall short of the capital needed. At the same time, the global innovation landscape is shifting, creating new opportunities. Emerging hubs like Abu Dhabi have shown that tailored support packages and access to capital and networks can attract entrepreneurs at scale.

Germany stands at a pivotal moment: Building on its strengths as a research leader, it has the chance to strengthen the innovation ecosystem, one that better enables entrepreneurs, supports responsible risk-taking, and improves the connection between research, talent, and capital. As the Draghi Report recently highlighted, boosting innovation capacity and industrial dynamism will be critical for Europe's long-term competitiveness, and Germany has a leading role to play [486].



COMMERCIALIZING LEADING RESEARCH

Unlocking the Commercial Potential of German Research

Germany is a global leader in innovation, ranking 3rd in the H-Index for research output compared to 7th in total startup output. The US, by comparison, has only twice the research output, yet 32 times the annual startup output [487, 488]. A key reason for this gap is the slow and complicated negotiation of spin-out terms between universities, founders, and investors [489]. Although university equity stakes have generally decreased over the past decade, investors continue to view significant university ownership in startups as unattractive [490].

Another obstacle is a lack of funding for research commercialization. Germany is particularly strong in fundamental research, which requires substantial risk capital to commercialize [484]. Yet, with 8.2B EUR in VC investment in 2024, Germany lags behind competitors such as the US (191B EUR) and the UK (16.4B EUR) [491]. A significant reason for this disparity is the limited involvement of pension funds, which are a key source of VC funding. In the US, pension funds contribute around 27% to VC funds, whereas in Germany, they contribute less than 1% [484].

The existing gap between research excellence and startup activity in Germany represents a significant opportunity. Germany can accelerate its startup ecosystem by streamlining university spin-out processes and increasing involvement from institutional investors.

> “In the US and UK, there are great role models for how the commercialization of research can work. Besides capital, setting a culture that favors entrepreneurship within academia is crucial.”
>
> Dr. Ricardo Schäfer, Zone II Ventures

Selected Players

cea · Fraunhofer · ETH zürich · cnrs · CSIRO · University of Cambridge · MIT · Stanford University · University of Oxford · Max Planck Gesellschaft

CLOSING THE SME-INNOVATION GAP

Addressing the Structural Challenges Holding Back German SMEs

Germany's innovation capacity is primarily driven by strong research output and R&D from large corporations [492]. In comparison, SMEs are losing their edge: SMEs' innovation share has declined consistently, and entrepreneurs are increasingly feeling held back [482, 493].

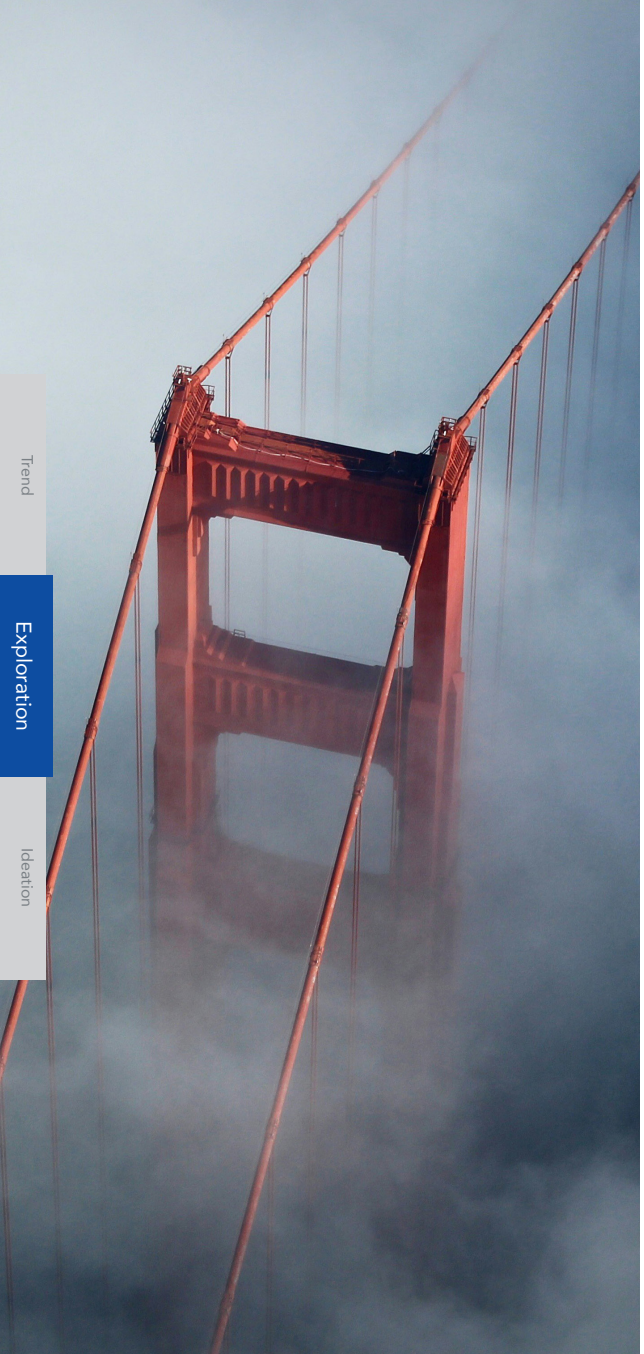
Structural challenges, including slow digitalization, excessive bureaucracy, limited access to finance and R&D incentives, and a shortage of skilled workers, hinder SMEs' innovative output [482, 483]. Specifically, SMEs face financial constraints due to high innovation costs, inadequate funding programs, and internal risk aversion, limiting their investment in innovation. For instance, firms that innovate without formal R&D are underrepresented in funding programs even though they create equivalent innovation "on the ground". Between 2010 and 2020, the share of these firms receiving support fell from 51% to 35%, while R&D-active firms saw their share increase from 49% to 65% [483].

Without targeted support and structural reforms, the innovation gap between large corporations and SMEs will likely widen. As Germany navigates the digital and green transitions, unlocking its SME sector's innovation potential is necessary and a significant opportunity for sustainable growth. It is also a chance to foster stronger collaboration between startups and SMEs, helping to unlock innovation potential and strengthen the ecosystem [494].

> "SMEs should lead the adoption of digital technologies. You see that much more in the US, where smaller firms are quicker, more able, and more open to adopting new tech than their European counterparts."
>
> Nina Odefey, Lakestar

Selected Players

Bundesministerium für Bildung und Forschung · Bayern Kapital Venture Capital für Bayern · bpifrance · DARPA · European Investment Fund · eXIST Existenzgründungen aus der Wissenschaft · FOND-ICO PYME · SPRIN-D Bundesagentur für Sprunginnovationen · VINNOVA Sveriges innovationsmyndighet · KFW



REVERSING THE STARTUP DRAIN

Towards a Truly Founder-Friendly Immigration System in Germany

Germany's efforts to become a European startup hub are hindered by a loss of ventures and talent to more founder-friendly environments, especially in DeepTech companies, which face a multitude of hurdles [481]. The lack of later-stage venture capital [495] and burdensome bureaucracy [480] are key factors driving this exodus.

Global migration trends present an opportunity to reverse this development. To provide a prominent example, 17% of Americans currently consider international relocation [496, 497]. Successful talent attraction models, such as the UAE's Hub71 [498], provide valuable lessons on attracting migrating entrepreneurs. Hub71's program lowers the barriers of moving to and founding in Abu Dhabi by offering a comprehensive support package next to its accelerator program, including free housing and healthcare, office spaces, and a network of local corporate and capital partners [499].

The complex process of applying for a residency permit as a self-employed entrepreneur makes immigration to Germany difficult to navigate. First endeavors facilitate entrepreneurial immigration to Germany, such as the Berlin Business Immigration Service or the Welcome Centers in Baden-Württemberg [500, 501]. However, none offer assistance covering the migration process from start to finish. By simplifying entrepreneurial immigration and offering integrated assistance programs, Germany could proactively attract migrating entrepreneurs in the years to come.

> "The current administrative burden of obtaining work permits in Germany is too high and does not contribute to a welcoming culture for high-skilled labor."
>
> Oliver Schoppe, UVC Partners

Selected Players

SBIR · STTR America's Seed Fund
Make it in Germany
startup estonia
IHK FOSA
FRENCH TECH VISA
BUSINESS IMMIGRATION SERVICE BERLIN
STARTUP SG NETWORK
Welcome Center BADEN-WÜRTTEMBERG
OptiMigration
HUB71

EXTERNAL DEPENDENCE

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

Rewiring Germany's Energy Future
Supplying the Future of Raw Materials
Future-Proofing Bavarian Agriculture

Fabian Hildesheim 
Henri Beyer 
Ilda Karaj 
Izabella Pavlova 
Vishwa Singh 

EXTERNAL DEPENDENCE

Reducing External Dependencies and Risks Through Strengthening Innovation

As global interdependencies grow, economic resilience and strategic autonomy are becoming increasingly vital for sustaining long-term innovation and competitiveness [502]. While being one of the strongest industrial economies in Europe [503], Germany relies on a global supply chain, making the country vulnerable to external disruptions [504]. Combined with its central geographic position, this leads to geopolitical and economic risks, highlighting the importance of building a more self-reliant, digitally robust, and future-oriented system [505].

While advancing in renewable energy generation, Germany still heavily relies on fossil fuel imports, representing more than 60% of total energy supply [506]. This dependence exposes businesses and consumers to energy price fluctuations and operational risks [507], ultimately affecting economic stability and the country's attractiveness for businesses and investors [508]. However, the adoption of renewables is hindered by slow permitting procedures, limited incentives for demand-side innovation, and slow digital integration. A more flexible and innovation-friendly regulatory framework could accelerate the transition to a resilient, low-carbon energy system while reducing reliance on external energy sources [509].

The challenge of raw material dependence presents similar risks for Germany's technology and industrial sectors [510]. As global demand for critical minerals rises, access to secure and diversified supply chains becomes a strategic imperative [511]. Germany's industrial output, particularly advanced manufacturing, relies on materials often sourced from regions with elevated geopolitical risk [512]. Expanding recycling infrastructure, developing material substitution strategies, and embedding circular economy principles across industries can reduce external dependencies and enhance resource security while delivering economic and environmental benefits [513].

In agriculture, the stakes are equally high. Bavaria's agricultural sector is under growing pressure to adapt to climate change [514]. While smart farming solutions are available in the market [515], integration of digital products remains limited. The lack of regulatory incentives to support adaptation [516] causes farmers to favor traditional models over transformative solutions [517]. Establishing targeted initiatives such as digital test sites and adoption subsidies can strengthen the implementation of innovative solutions and ensure long-term food security [518].

Taken together, these interconnected domains illustrate a broader consideration: the need to reduce external vulnerabilities not only to strengthen economic sovereignty but also to create the stable foundations necessary for a thriving innovation ecosystem. By embracing proactive policy reform, strategic investment in technology adoption, and regulatory agility, Germany can safeguard its current economic position and lead in building resilient, sustainable systems for the decades to come.

REWIRING GERMANY'S ENERGY FUTURE

Addressing High Energy Imports with Renewable Innovation

Energy imports comprise 70% of Germany's primary energy supply [519]. This heavy reliance exposes the country to price volatility and high costs [520]. Approximately 60% of European companies cited high energy costs as a significant barrier to investment in 2023 – over 20% higher than their U.S. counterparts – underscoring the negative implications for industrial competitiveness and innovation [521].

While Germany has made substantial investments in renewable energy production [522], reaching 57% of renewable electricity generation in 2024 [523], the integration of new technologies and permitting delays persist [524]. Regulatory barriers, such as Bavaria's 10H rule [525] – enforced from 2014 and only recently relaxed [526, 527] – blocked wind energy expansion for nearly a decade. Additionally, the carbon pricing system introduced in 2021 for transport and buildings [528] has faced criticism [529] for lacking flexibility mechanisms, leading to higher costs for businesses without encouraging real time energy optimization [529].

As technology in AI and automation for energy management advances rapidly, Germany's slow digitalization and lack of clear regulatory frameworks, especially for dynamic pricing and peer-to-peer energy trading, create a widening gap between potential and actual adoption. Financial incentives continue to prioritize generation capacity over intelligent energy use, leaving innovative startups with limited support [530].

> "Achieving true energy independence is the fundamental driver that will enable long-term innovation, economic resilience, and shared prosperity for future generations."
>
> Dr. Pasha Shabalin, Marvel Fusion

Selected Players

Enpal · RWE · EnBW · 1KOMMA5° · thermondo · Ørsted · VATTENFALL · enercity positive energie · ERG EVOLVING ENERGIES · eni

SUPPLYING THE FUTURE OF RAW MATERIALS

Tackling Skewed Supply Chains with Recycled Materials

Germany depends on 34 critical raw materials [512], with around two-thirds imported from outside the EU [531]. Critical minerals such as lithium, cobalt, and rare earths are used in high-tech products. Electronics, end-of-life-batteries, and other e-waste can serve as valuable urban mines for these critical minerals [532]. Recycling already meets 14% of Germany's raw material needs, replacing otherwise necessary imports of 12B EUR [533]. Fully closing material loops could offset up to 90B EUR annually [533]. Substitution strategies, like the replacement of cobalt-based with lithium-iron-phosphate batteries, further reduce reliance on scarce resources [533].

This transformation is supported by the EU's Circular Economy Action Plan and Critical Raw Materials Act. The latter set ambitious targets of achieving 25% consumption for recycling and reducing reliance on any non-EU country to below 65% by 2030 [534, 535]. Meeting these targets requires policy support, especially incentives for recycled materials usage, as primary imports remain cheaper and easier to source [536].

Due to many clean-tech products not having reached end-of-life yet, the visible impact of recycling is limited. As they become more prominent, the effect will grow significantly over time [537]. Building recycling capacity requires an upfront investment, but it diversifies supply and buffers against market volatility [538]. EU support via recycling mandates or guaranteed purchase agreements will drive innovation in recycling capacity and material substitution research [535].

> "Electronic devices tend to have highly concentrated amounts of rare earth metals. Therefore, recycling and circular business models pose a huge opportunity for Germany to become a key importer of goods."
>
> Oliver Schoppe, UVC Partners

Selected Players

eit RawMaterials · AMDC African Minerals Development Center · Global Battery Alliance · MIRECO The key force in closing the cycle · ESMIN · VALE · GLENCORE · 中国黄金 China Gold · EMC Resourcing a sustainable future · SD-GOLD 山东黄金 SHANDONG GOLD

FUTURE-PROOFING BAVARIAN AGRICULTURE

Adopting Digital Technologies to Boost Farms' Resilience

Climate change and extreme weather events threaten Bavarian agriculture by impacting soil health, water resources, and biodiversity [539]. Despite 841M EUR in subsidies supporting sustainability, animal welfare, and climate resilience within agriculture [540], adoption of digital technologies in this sector remains critically low [541]. Only 9–12% of Bavarian farmers utilize advanced sensing technologies like drones or satellite systems [431]. However, research indicates that in the next five years, adoption rates can increase to 15–20% for technologies such as barn robotics, section control, variable-rate applications, and maps from satellite data [541].

Bavaria lacks targeted initiatives to transform legacy subsidies like agricultural diesel and milk price bonuses into progressive incentives that promote innovation [542]. Early subsidizes for new technologies pave the way, e.g., precision farming is subsidized with 80 EUR per hectare [543]. Similarly, establishing agricultural regulatory sandboxes [544] in Bavaria could provide controlled environments for testing prototypes under softened regulatory conditions, increasing the speed of innovating, developing, and adopting these technologies regionally. Targeted policies promoting technology adoption and regulatory flexibility could enhance Bavarian agriculture's resilience and sustainability further while aligning economic benefits with environmental goals [545].

> "We see a significant shift of food-tech startups moving to Singapore due to regulatory overload. This is very sad to see as we are spearheading research but then blocking commercialization efforts."
>
> Dietmar Harhoff, Max Planck Society

Selected Players

PIVOT BIO, Mosa Meat, indigo, Eden Genetics, Holloid, KWS, Climate FieldView, OneSoil, TARANIS, NETAFIM An Orbia business.

GOVERNMENT UNDER PRESSURE

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

Agent-Based Process Automation of Requests

Shared Data Interfaces

Rebuilding Trust Through Artificial Intelligence

Isabel Blank-Aschauer 
Joël Hainzl 
Johannes Michalke 
Jonas Clotten 
Joshua Kraft 

GOVERNMENT UNDER PRESSURE

Reimagining Governance by Leveraging Technology for Resilience, Efficiency, and Trust

German public administration is under pressure to develop and transform its operations. Decades of fragmented IT infrastructure, rising public expectations, and growing geopolitical uncertainty expose outdated system limitations [546]. Among many challenges, three are particularly critical: slow technological adoption, declining citizen trust and participation, and inefficiencies caused by disconnected data systems [547, 548, 549]. In Germany, these issues are responsible for an estimated 146B EUR in annual economic losses, with 70% of firms identifying red tape as a barrier to growth [550, 336]. However, emerging developments such as AI-powered process automation, digital tools to rebuild public trust, and shared data interfaces that bridge existing system silos offer promising solutions.

The first opportunity lies in automating resource-intensive administrative processes. 27% of civil servants will retire within the next decade, and staff are already overwhelmed by current workloads [551, 552]. AI-powered verification tools offer a solution to ease this burden. Machine learning models can extract information, validate documents, and support decision-making [553]. Germany's Online Access Act lays the groundwork, while projects like Modul-F demonstrate that AI-based verification can be embedded into administrative workflows [554, 555]. However, adoption stalls when these tools cannot integrate into legacy backends, highlighting that innovation is ineffective without system-wide compatibility [556].

Another problem is that trust deficits undermine governance; only 36% of Germans trust the government, compared to an OECD average of 39% [557]. Digital engagement platforms and AI-powered communication tools offer the potential to address this issue by delivering personalized information, such as local-language chatbots used in India, and by analyzing citizen feedback at scale. When natural language processing uncovered overlooked local concerns in the Philippines, it demonstrated how AI could turn bureaucratic responsiveness from theory into practice. This is possible if tools can access unified, cross-departmental data [558, 559].

A fragmented digital infrastructure underpins both slow adoption and weak engagement. Germany's public sector runs on a collection of isolated IT systems, where even basic tasks like school administration often require duplicate data entry across incompatible platforms [560]. Although complete centralization demands constitutional reform, international models such as Estonia's X-Road demonstrate that standardized APIs enable virtual integration across diverse systems [561, 562].

These developments paint a clear path forward. AI can ease staffing pressures and help restore citizen trust. Shared data interfaces can reduce inefficiencies if implemented as interconnected solutions. The alternative future is unsustainable if governments continue spending billions to uphold fragmentation while citizens and businesses increasingly disengage. The necessary technologies are already available; what is needed now is the vision to weave them into a coherent strategy for the public sector.

AGENT-BASED PROCESS AUTOMATION OF REQUESTS

Automating Document Checks in Times of Staff Shortage in Government

Germany's public administration can no longer delay modernization efforts [563]. In particular, checking and verifying applications and documents ties up considerable resources, as it is often still done manually. In 2023 alone, staff processed 1.9M visa applications and 350k requests for asylum [564, 552]. The situation worsens as around 27% of civil servants will retire in the next decade [551]. The remaining employees will have to take on administrative tasks and lose time for strategic projects and personal development.

Increasing administrative work and staff shortages present a promising opportunity to use AI in document verification. AI models can automatically extract information from documents, verify it, and support employees in making decisions [565]. In the future, AI systems could make better decisions than humans, being less affected by emotions or a lack of information [566]. Hence, AI-powered document verification could help address systemic challenges while laying the groundwork for scalable improvements in efficiency and resource allocation in a sector heavily burdened by documentation processes.

With an investment of over 3B EUR in the Online Access Act, Germany is digitizing its public sector [567]. One project is Modul-F, a modular software for administration that will enable AI-based document verification [555]. Despite these developments and benefits, establishing clear accountability for decisions made by AI systems remains a key challenge.

> "Agents can hold an unlimited number of legal texts in memory, whereas this is not possible for the human brain. Thus, decisions can be made in a more well-informed and thorough manner."

Alexander Wunsch, Regierung von Oberfranken

Selected Players

CBRAIN The Process Company · Konfuzio · Deep Cognition · DocuWare · GovOS · Jotform · ABBYY · polyteia · SIMPLIGOV · VISARIGHT

SHARED DATA INTERFACES

Unlocking Seamless Governance in a Fragmented Digital Landscape

Germany's public administration relies on numerous specialized IT systems that often operate in isolation, causing inefficiencies, redundant data storage, and error rates [568]. For instance, the VIVA software manages civil servants in Bavarian school administration, while a separate system handles teacher trainees. Data is duplicated as systems do not communicate, creating unnecessary work and inconsistencies, even within the same agency [560]. Expert interviews with the Bavarian Agency of Digital Affairs (Byte) revealed that cross-agency integration is even more problematic [561].

This fragmentation largely stems from decentralized procurement, where each agency selects its IT systems, resulting in an array of disconnected solutions [568, 560]. While one unified system is often suggested, experts like Antonia Zierer from Byte note that this would require constitutional reform [561]. Moreover, complete centralization may not be desirable, as the competition among solutions spurs innovation [569].

A bottom-up approach offers a more viable and effective alternative by introducing standardized, secure data interfaces (e.g., APIs) to connect existing systems. These would reduce redundancies, streamline processes, and improve data quality. International examples like Estonia's X-Road and the UK's API catalog demonstrate that such integrations enhance administrative efficiency and create a more citizen-friendly public sector [562, 570].

> "Buying one centralized solution reduces vendor competition, potentially leading to worse outcomes."
>
> Dr. Ricardo Schäfer, Zone II Ventures

Selected Players

zapier · Amazon API Gateway · OPENGOV · matrix · MuleSoft · ORACLE NETSUITE · Palantir · SAP · tyler community · X-ROAD

REBUILDING TRUST THROUGH ARTIFICIAL INTELLIGENCE

How Digital Tools Can Strengthen Democratic Communication and Participation

Global trust in governments has declined, with research confirming a decades-long erosion of confidence in public institutions [571]. In the US, this trend worsened under polarizing leaders and rising media skepticism [572]. A key response to this crisis is strengthening public communication by increasing government efforts to inform, listen, and engage with citizens outside of election periods [573].

Studies show that proactive communication increases trust in institutions, while public participation enhances satisfaction with political outcomes [574, 575, 576]. Governments should pursue two strategies to leverage this. First, deliver information effectively. Especially younger citizens prefer low-effort and digital access to political information [577]. Thus, AI-powered tools like chatbots can improve engagement and political efficacy [578]. In India, such tools allowed rural communities to access government information in local languages [558]. Second, gather more citizen feedback. AI enables large-scale feedback collection through digital platforms and by analyzing public sector discourse on social media. In the Philippines, for instance, large language models can extract location-specific concerns and identify previously unnoticed local issues [559]. If integrated effectively, these tools can turn the trust crisis into an opportunity for democratic renewal [579].

> “Why make people fill out a seven-page form when a chatbot could guide them through the same process in a conversational format?”
>
> Oliver Schoppe, UVC Partners

Selected Players

abgeordnetenwatch.de · Agora Digitale Transformation · bangthetable · citibeats · CONSUL open participation · go vocal ehem. CitizenLab · MAKE.ORG · Neighborland · SUMM · zencity

WORKFORCE SKILLS GAP

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

AI Adoption Gap in the German SME Workforce
Soft Skill Deficit in Germany's Workforce
Workforce Retraining for Critical Sectors

Carla Appel 
Fynn Schäfer 
Jorge Vincentelli 
Lena Ehrenreich 
Sven Ader 

WORKFORCE SKILLS GAP

Equipping the Workforce for Future Jobs in a Changing Technological and Demographic Landscape

Germany faces unprecedented challenges as the technological transformation of digitalization, automation, and AI reshapes how economic value is created by shifting from traditional manufacturing processes to data-driven business models [580]. This reveals a structural need for new forms of state-supported workforce education to ensure inclusive participation in future economic progress, an urgency further amplified by demographic shifts [581]. The German workforce is aging rapidly, with a forecasted 11.2% decline in the working-age population between 20 and 64 years by 2030, significantly higher than the EU average of 6.9% [582]. Technological advancements and demographic pressure place an increasing strain on a comparably old workforce with a median age of 45.5 in 2024 [583]. This is reflected in low levels of digital proficiency across the population, where only 52.5% of people in Germany have just basic digital skills [584]. Despite some employer support, the burden of upskilling disproportionately falls on the most vulnerable labor market segments, such as older and low-paid workers [585]. In many cases, this requires not just updating skills but undertaking complete retraining to shift into new occupational fields. Yet, the German education system, which could serve as a support mechanism, is primarily designed for initial career preparation rather than ongoing retraining, lacking flexible structures to help requalify these parts of the workforce [586]. Overall, these circumstances give rise to a systemic problem: How do we prepare the current workforce for the evolving demands of tomorrow's economy?

The first issue is Germany's slow and inconsistent adoption of Artificial Intelligence (AI) solutions. In 2024, only 27% of German companies used AI in their daily operations despite the significant development over the past years. This adoption gap appears especially pronounced among SMEs and older employees [587].

The second challenge relates to the growing demand for upskilling, particularly among workers whose formal education dates back many years, as many individuals need to relearn how to learn [581]. This calls for upskilling the workforce in essential cognitive abilities like critical thinking, creativity, and mental resilience to enable adaptive work in technology-driven environments [588]. The rise of AI and automation further requires employee education to move beyond hard skills [589].

The third challenge lies in large-scale occupational transitions, which demand comprehensive workforce reskilling to prepare for new roles. For example, Germany is projected to require an estimated half a million additional nursing staff by the mid-2030s [590], while the automotive sector is expected to reduce its workforce due to increasing global competition and a shift toward electrification [591].

To address these obstacles, policymakers must collaborate with the private sector to build a dynamic and inclusive upskilling and reskilling ecosystem. This should align with evolving skill demands, support lifelong learning, and ensure the workforce can thrive in a rapidly changing economy.

AI ADOPTION GAP IN THE GERMAN SME WORKFORCE

Lack of AI Skills Among Workers is Limiting Productivity and Innovation in SMEs

AI adoption among German SMEs remains uneven, with smaller firms lagging due to structural challenges that limit their capacity for digital transformation and AI adoption [592]. These challenges include regulatory burdens, e.g., the Supply Chain Act [593], workforce shortages that leave little time for exploring new technologies [594], and a lack of internal technical expertise [595].

While larger SMEs with 250+ employees are making strides toward AI adoption, smaller ones often face barriers to AI uptake, such as low digital maturity [596]. However, new AI tools offer more intuitive, user-friendly interfaces, usually based on natural language or guided workflows [569].

At the same time, the rise of low- and no-code platforms empowers non-technical staff to integrate AI into everyday processes. As the new digital-native employee generation enters the workforce equipped with AI tools, indirect pressure accelerates bottom-up adoption. Together, these trends present a critical window for AI solution providers to support SMEs – by reducing complexity, aligning with operational realities, and offering tools that meet users where they are.

> “AI tools are now plug-and-play. That’s why this wave of adoption will be faster, even for SMEs.”
>
> Dr. Ricardo Schäfer, Zone II Ventures

Selected Players

ARRI, Fissler, HARTING, igus, KÄRCHER, KRONES, Miele, TRUMPF, VIESSMANN, wilo

SOFT SKILL DEFICIT IN GERMANY'S WORKFORCE

Bridging the Gap Between Education and Industry Expectations

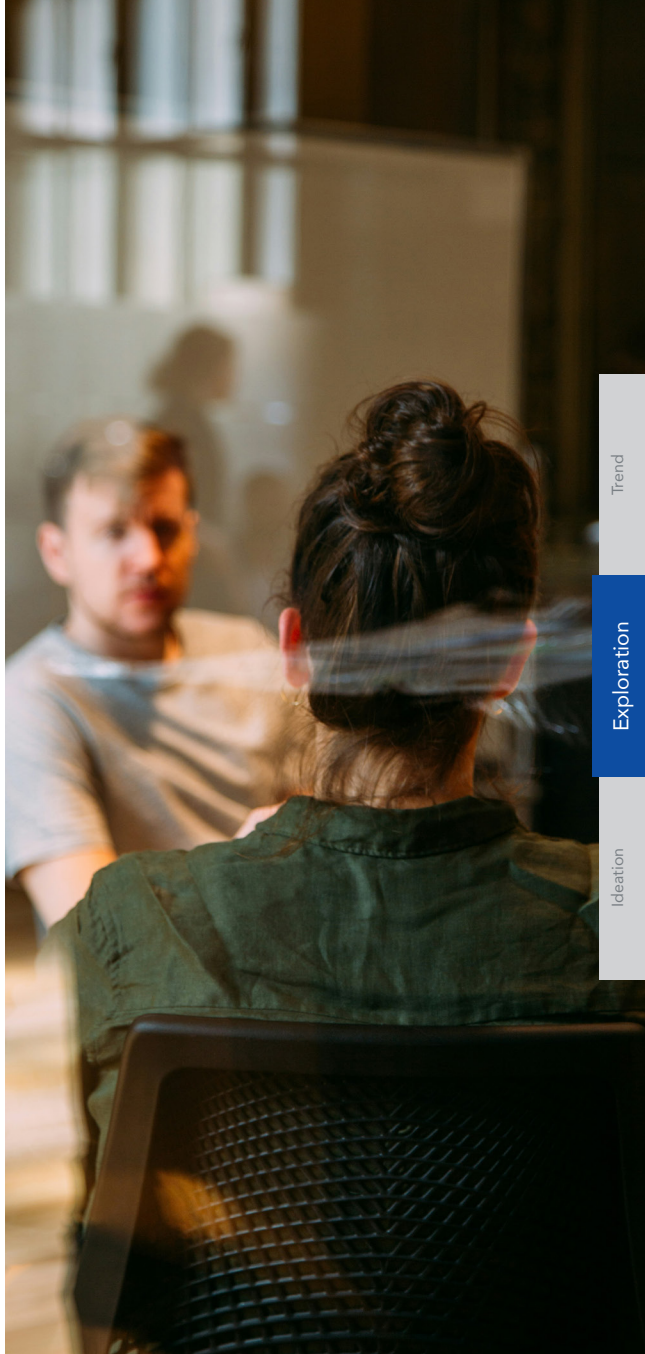
There is an increasing demand for soft skills in the German workforce [597], yet formal education prioritizes academic content over transversal skills like critical thinking, creativity, and communication [598]. Following the PISA shock in the early 2000s, German education policy intensified efforts in teaching core subjects like math and science [599]. As a result, students often graduate without the interpersonal skills needed in the modern workplace. The disconnect is evident in mismatched perceptions: while 74% of education providers feel confident that graduates are work-ready, only 35% of employers agree [600].

Modern work is highly collaborative and depends on creative and critical thinking, driving an increased demand for soft skills. In 2023, two-thirds of job ads required these skills, a trend that continues to grow with the rise of AI [601]. The automation of jobs is increasing the value of human-centric skills that cannot be replaced by machines, such as emotional intelligence, creativity, and innovation [602]. Employees trained in a rigid system that prioritizes memorization and method learning will lack the soft skills necessary to work in a rapidly changing world [603]. If this skill gap is not addressed, it could significantly hinder German productivity and innovation. An opportunity arises to upskill workers into adaptable and creative thinkers who can effectively leverage emerging technologies.

> "If everyone has similar access to the amount and quality of information, it is more about how you use that information and what skills you have."
>
> Nina Odefey, Lakestar

Selected Players

360learning · humans · centrical · Colleva · LinkedIn Learning · Pact for Skills (An initiative of the European Commission) · Pact for Skills · PRAXIS LABS · Sana · VirtualSpeech



WORKFORCE RETRAINING FOR CRITICAL SECTORS

Empowering Displaced and Inactive Workers to Meet Germany's Skilled Labor Demands

Germany faces a disconnect between labor market demands and available skills. In 2023 and 2024, the country had a shortage of over 530,000 skilled workers, with the most significant gaps in healthcare, construction, and public administration. However, due to a mismatch between the qualifications of job seekers and the skills required, only 41% of these positions can be filled by those currently unemployed [604]. Key drivers include the demographic shift, over-academic orientation of the youth [605], and insufficient labor market integration of migrants [606].

By 2035, the working-age population is projected to shrink by 4-6M due to an aging demographic, further increasing skill deficits [607]. At the same time, between 6% and 30% of jobs in Germany are at high risk of automation through AI and other technologies [608]. This raises the question of where automation will displace jobs, which skills will be needed, and how reskilling pathways must differ between blue- and white-collar workers. While automation in blue-collar sectors is often limited by structural and practical constraints, white-collar jobs, particularly those based on knowledge work, are more exposed to disruption, as their digital nature allows for faster and more profound transformation [556]. This situation presents an opportunity to reeducate citizens facing job uncertainty and guide them into fields that will remain in high demand, thereby reducing unemployment, increasing productivity, and better leveraging new technologies.

> "Reskilling is a product challenge as much as a policy one."
>
> Oliver Schoppe, UVC Partners

Selected Players

Bundesagentur für Arbeit · coursera · DB Training, Learning & Consulting · edX · FernUniversität in Hagen · IBM SkillsBuild · UDACITY · PLURALSIGHT · skillsoft · Workera

RESILIENT INFRASTRUCTURE

INFLUENCING THE FUTURE OF POLICY-ENABLED INNOVATION

Resilient Energy Infrastructure
Climate-Resilient Communities
Digital Cyber Resilience

Ahmed Rezik 
Ece Özdağ 
Elena Herzog 
Julian Ehrenbrandtner 
Paul Zeller 

RESILIENT INFRASTRUCTURE

Future-Proofing Germany's Infrastructure Against Climate and Systemic Risks

Resilient infrastructure refers to the capacity of critical systems, such as energy grids and digital networks, to withstand disruptions and recover quickly [609]. In practice, this means anticipating risks, absorbing shocks, adapting to changing conditions, and restoring essential functions rapidly to ensure consistent access to essential utilities, transport, and digital infrastructure [610].

As Germany faces significant challenges that are exposing infrastructural vulnerabilities, the country's infrastructure resilience has become a key priority [611]. The frequency of extreme weather events, such as heavy rainfall or heat waves, increases due to climate change, placing growing pressure on communities and essential services [612]. The resulting damages have highlighted vulnerabilities, underscoring the urgent need for systemic resilience to safeguard lives, economic stability, and environmental health [613]. Furthermore, the disruption of Russian gas supplies has exposed Europe's energy dependency and reinforced the urgent need for resilient energy systems [614]. Lastly, the ongoing expansion of Germany's digital infrastructure makes the country more vulnerable to cyber threats. The operators of critical IT infrastructure reported 490 disruptions from June 2022 to June 2023 [615]. Given the increasing reliance on digital systems to run everyday services like healthcare and utilities means that cyber resilience is no longer optional, but an essential safeguard to protect national security, economic integrity, and democratic processes [616].

Germany has reached a tipping point, recognizing the urgent need to modernize and future-proof its infrastructure. In response, it recently announced a landmark 500B EUR infrastructure investment package, with one-fifth of the fund allocated for climate-related measures [617, 618]. This shift is highlighted by the recently introduced KRITIS Umbrella Act, establishing Germany's first unified legal framework for critical infrastructure protection. By establishing minimum resilience standards, enhancing risk analysis, and formalizing oversight structures, the act demonstrates Germany's acknowledgment that resilience is a strategic necessity [619]. It's crucial to withstand and quickly recover from the impacts of climate change, maintain uninterrupted energy supplies amid geopolitical volatility, and protect critical digital assets against evolving cyber threats.

At the same time, these changes also present a timely opportunity for innovation. With unprecedented public investment and strong policy momentum, now is the time to rethink the systems that underpin the German economy and society. In the following sections, three high-potential areas for innovation are explored: climate-resilient communities, cyber resilience, and resilient energy infrastructure.

RESILIENT ENERGY INFRASTRUCTURE

Securing Energy Infrastructure for an Electrified, Sovereign, and AI-Driven Economy

Germany faces rising electricity demand as industry, heating, and mobility electrify. The federal grid agency projects electricity consumption could double by the mid-2030s [620], while Europe's data centers may nearly triple their power usage by 2030 [621]. Further, geopolitical conflicts emphasize the need for more resilient infrastructure. This surge exposes key vulnerabilities, as current grids cannot handle high volumes of renewable energy from decentralized and intermittent sources, risking shortages and instability [622].

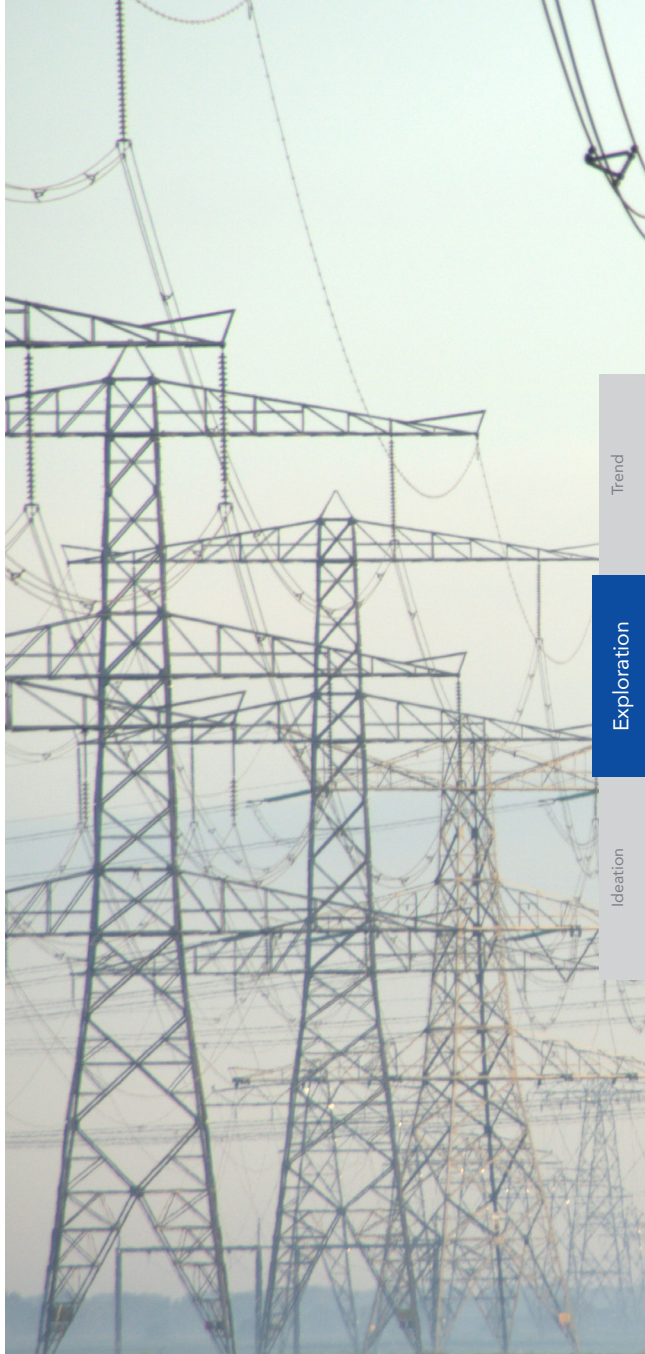
Momentum is growing with at least 100B EUR of Germany's infrastructure fund designated for climate and energy projects [623]. Additional grid investments are planned until 2035, reflecting the urgent need for better transmission infrastructure [624]. Despite regulatory hurdles, a big opportunity lies in innovative, resilient solutions to modernize and expand energy infrastructure, particularly through advanced storage, smart grids, decentralized renewable systems, and underground cable installation [625, 626, 627].

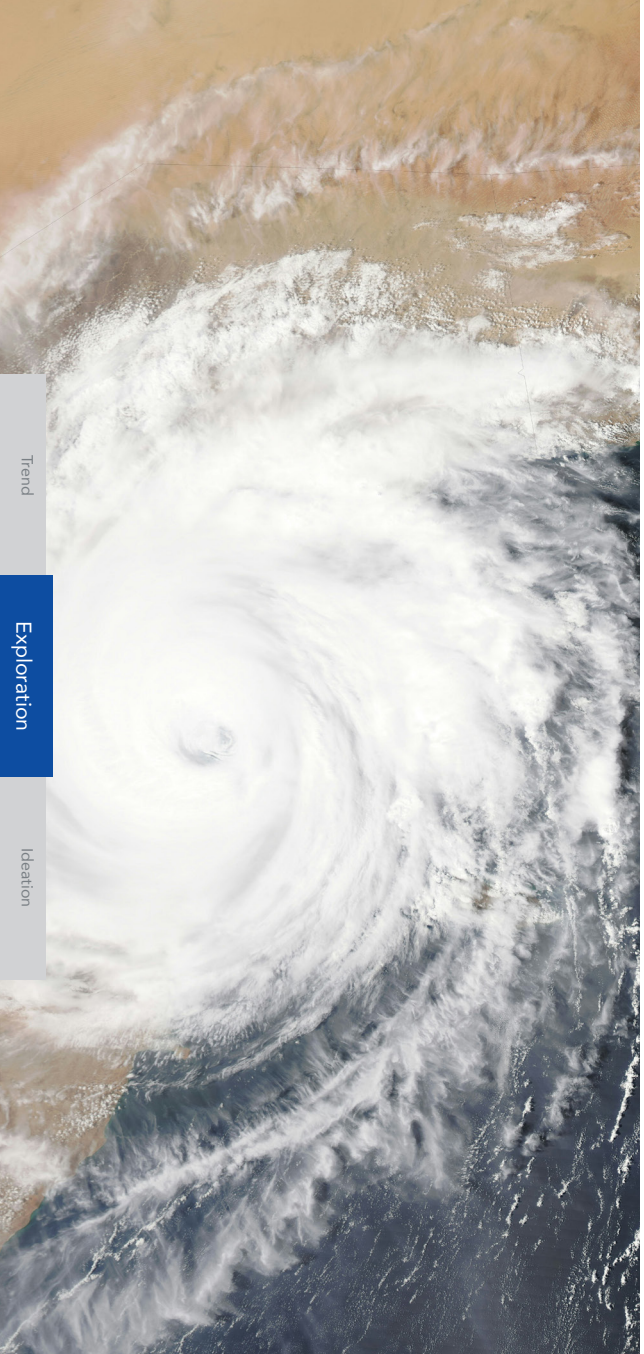
Companies developing new forms of energy generation, smart energy platforms, and virtual power plants can capitalize on substantial growth opportunities [628]. Moreover, startups using AI forecasting, automated demand-response, and efficient energy distribution technologies will lead to market evolution. Addressing infrastructure limitations with innovation will secure Germany's competitiveness and advance climate goals.

> "Innovation is stuck in outdated rules, slow approvals, and a grid system driven by the wrong incentives. If we want real flexibility, we need to design digital, dynamic infrastructure that reflects how energy actually flows today."
>
> Steffen Schülzchen, Entrix

Selected Players

MarvelFusion · VEIR · envelio · next THE POWER OF MANY · Proxima Fusion · THALERON · Plexigrid · enspired · SKELE+ON TECHNOLOGIES · Entrix





CLIMATE-RESILIENT COMMUNITIES

Extreme Weather Adaptation and Mitigation Using Weather Data

Over the past two decades, Germany has witnessed many extreme weather events, including floods, storms, droughts, and heatwaves. These events have had a significant impact on livelihoods, the environment, and the economy [506, 629, 630]. Looking ahead, the expected damages of extreme weather events will range from 280-900B EUR by 2050, potentially affecting up to 1.8% of Germany's annual GDP [506].

To navigate this challenge, early detection of extreme weather risks is crucial, achievable by gathering accurate weather data via satellites, drones, and other technologies [631, 632]. Germany is one of the leading countries regarding weather data collection. However, businesses and the government still struggle to develop actionable solutions and policies to address the implications of changing climate [633]. While it is clear that investments in weather forecasting and early warning systems save lives, protect assets at relatively low cost [634], and play a key role in establishing mitigation and adaptation strategies, the available data remains underutilized [635, 636, 637].

Proper data utilization creates an opportunity to make physical infrastructure more resilient to extreme weather by supporting vulnerability mapping, early warning systems, and climate-informed planning [638]. It also supports planning in areas such as urban development, agriculture, water management, transportation, and carbon sequestration by identifying high-potential and high-risk zones [639, 640], while improving early warning systems and disaster preparedness [641].

> "By leveraging AI, ML, and advanced data collection tools like satellites and drones, we can transform weather data into actionable insights, helping industries and cities to anticipate environmental challenges."

Oliver Schoppe, UVC Partners

Selected Players

meteomatics, WindBorne, AccuWeather, CURB Tool, DTN, Deutscher Wetterdienst Wetter und Klima aus einer Hand, DWD, ISALA Xweathe, spire | weather, UBIMET WEATHER MATTERS, tomorrow.io

DIGITAL CYBER RESILIENCE

Strengthening the Digital and Cyber Foundation of Critical Infrastructure

Cyberattacks have evolved from phishing and malware to coordinated AI-driven campaigns and ransomware-as-a-service, targeting individuals, enterprises, and critical infrastructure [642]. As utility providers are increasingly adopting digital technologies, the attack surface widens, exposing water, energy, and electrical services to risks that disrupt essential services and daily life [643].

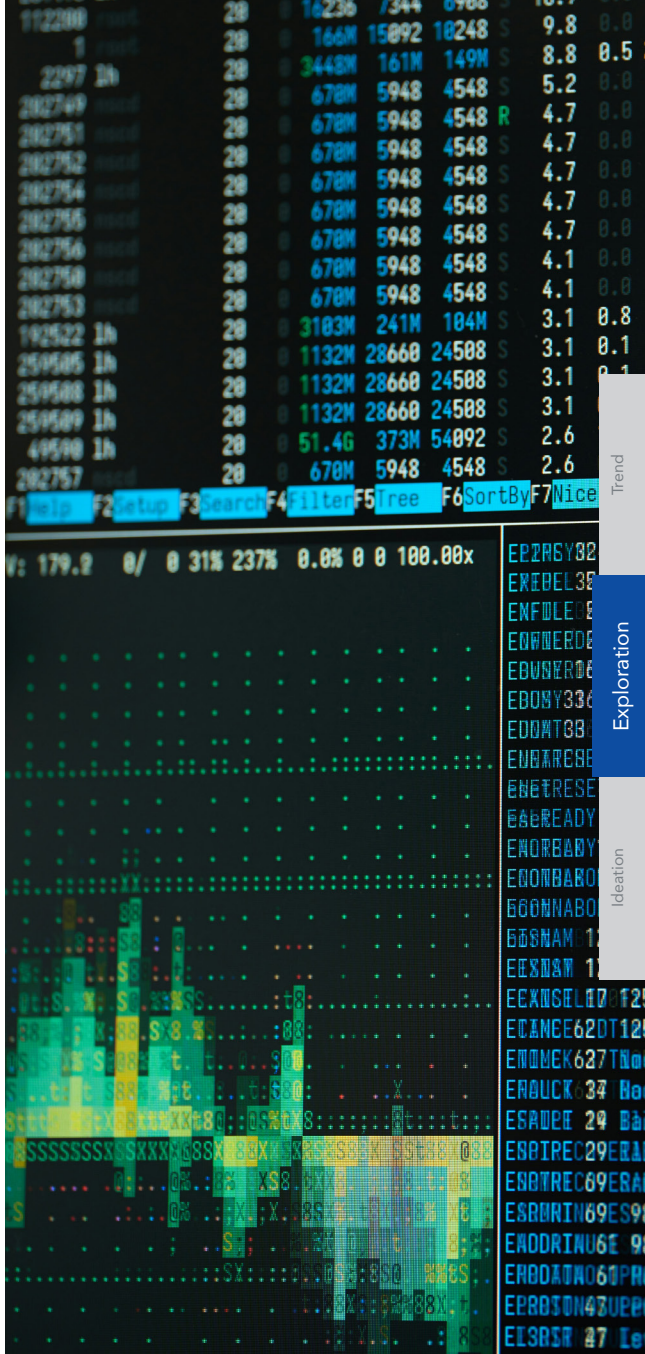
The financial toll is staggering: cybercrime damages soared from 3T USD in 2015 to 8T USD in 2023 and are projected to hit 10.5T USD in 2025 [644]. To counter this, regulatory frameworks are tightening. For example, the Network and Information Security Directive 2 is a European legal framework implemented to strengthen cybersecurity across critical sectors. It mandates stricter risk management measures, like 24-hour incident reporting and better supply chain oversight. It marks a move from national policies like IT Security Act 2.0 toward unified EU standards focused on resilience [645, 646]. Meanwhile, the European Union's Digital Operational Resilience Act introduces uniform ICT risk management for the financial sector, focusing on tailored cybersecurity strategies [647].

Moreover, mass data collection can be misused for political manipulation, as shown by the Cambridge Analytica scandal, where millions of Facebook profiles were harvested to influence political campaigns [648]. With rising data broker activity and foreign influence campaigns, cybersecurity must defend systems and protect democratic integrity [649].

> "We need a really strong digital and technological backbone for our resilience."
>
> Boris Pistorius, German Minister of Defence

Selected Players

schwarz digits · Bundesamt für Sicherheit in der Informationstechnik · CROWDSTRIKE · DARKTRACE · DREAM · enisa · eset · ECCC · SOPHOS



IDEATION

The following chapter describes five novel ideas of great relevance for *The Future of Policy-Enabled Innovation*, especially in view of the identified future trends. Each of the ideas is developed to solve a specific problem in the identified problem spaces.

Jakob Mayer 
Maaz Ahmed 
Mara-Jean Krupa 
Max Rosenblattl 
Sven-Christian Hörner 

BayernBoost

Bavaria's One-Stop Digital Platform to Launch Startups Fast

Germany ranks 125th out of 191 countries when it comes to the ease of starting a business [650]. This ranking reflects a systemic challenge: Germany is losing talent to more founder-friendly environments, with bureaucracy among the most cited obstacles [651]. While a digital registration process technically exists, it remains fragmented, time-consuming, and complex, especially for international founders. BayernBoost addresses these shortcomings by simplifying and digitizing the entire company formation process.

BayernBoost is Bavaria's official one-stop digital platform for company formation, designed to revolutionize how both native and international entrepreneurs launch their businesses. Whether registering a company or applying for an entrepreneurship visa, founders can now access a unified and user-friendly service that replaces friction with simplicity, reducing setup time from weeks to just days.

Starting a business in Bavaria currently requires navigating multiple agencies, applications, and language barriers. BayernBoost replaces this complexity with a fully integrated digital solution. Every essential step, from identification and insurance to notarization and bank account setup, can be completed via a single, secure platform. All workflows are available in English by default, making Bavaria a compelling choice for international founders deciding where to launch their startup. Furthermore, the platform strongly simplifies the visa application process to attract international founders to Germany.

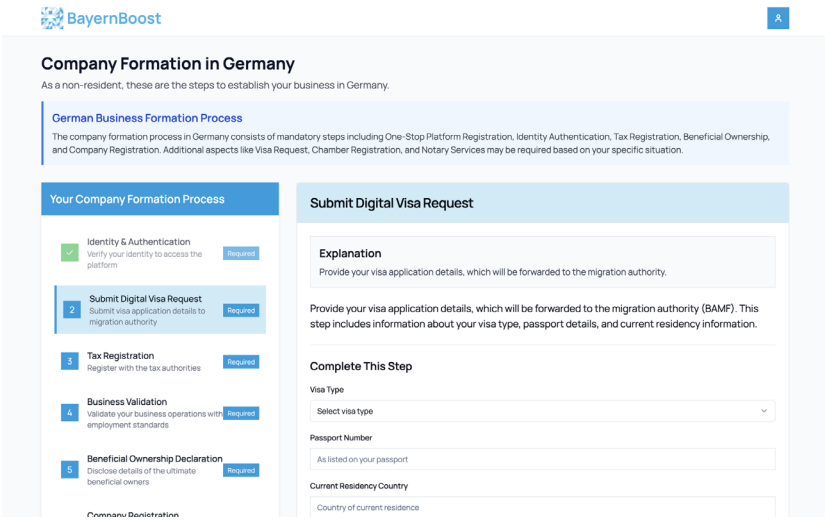
BayernBoost unlocks Bavaria's untapped innovation potential by eliminating bureaucratic friction and turning obstacles into economic impact. Bavaria already boasts one of Europe's strongest innovation ecosystems, as it is home to top universities, global technology leaders, and cutting-edge startups. BayernBoost builds on this foundation, making choosing Bavaria for startup incorporation easier and more attractive.

Growth in the local startup economy will boost tax revenues, attract global talent, and strengthen the startup ecosystem that generates jobs and prosperity. The platform also positions Bavaria as the blueprint for federal and EU-level integration, demonstrating what modern, founder-friendly digital public infrastructure can look like. With BayernBoost, Bavaria positions itself as the new global startup hub.

Problem

- A fragmented legal and bureaucratic landscape forces entrepreneurs to navigate multiple agencies and complex regulations, significantly delaying company formation [652]. The absence of a unified platform further compounds the challenge, as founders must manually re-enter data across disconnected systems.
- Germany ranks 125th out of 191 in ease of starting a business [650], highlighting systemic inefficiencies that discourage both local and international founders.
- Persistent language barriers and a lack of targeted support disadvantage international founders, particularly first-generation migrants, who face German-only forms and complex procedures that limit their chances to succeed as entrepreneurs [653].
- Only 3% of scientists in Germany become entrepreneurs, despite 28% expressing interest [654]. This reflects a system that doesn't reward or enable knowledge transfer through company building, especially for international researchers.

Ditch bureaucracy by cutting red tape to unlock a startup-friendly Germany which attracts global talent and fosters innovation.



Solution

- A fully digital one-stop platform for key services, including company registration, tax ID applications, banking integration, and secure onboarding using eIDs for EU and other trusted countries.
- The introduction of English as an official administrative language, supported by dual-language laws and legally binding forms, and AI-powered real-time translation in public services to eliminate language barriers.
- A low-barrier entrepreneurship visa tailored for international founders, offering flexible capital requirements, accelerated and binding processing timelines, and family-inclusive residency permits, all accessible through a single unified platform.
- A dynamic public-private ecosystem that connects state authorities, financial institutions, academia, and industry to foster collaboration, streamline processes, and provide holistic support for entrepreneurs.

By addressing systemic barriers to founding a startup, BayernBoost can transform Bavaria into a leading destination for entrepreneurs worldwide.

Market

- Other European countries outpace Germany when looking at startups per capita. With only 227 startups per one million inhabitants, Germany is lagging behind countries like Estonia, the UK, and France, with 1090, 574, and 307 startups per one million inhabitants, respectively [655].
- If Germany were to match Estonia's level of startups per capita, this could create roughly 11,000 additional startups in Bavaria alone, generating up to 180,000 new jobs in the start-up sector [656].
- Beyond the startup sector, the positive economic effects on the Bavarian economy could be further amplified by creating an estimated 540,000 additional indirect jobs [653].
- In addition to creating jobs, startups generate productivity gains, attract investment, and boost economic resilience, especially in digital, green, and innovation-driven sectors, strengthening Bavaria's global economic competitiveness [657].

By unlocking its untapped potential as a destination for founding, Bavaria can drive job growth, innovation, and economic resilience.

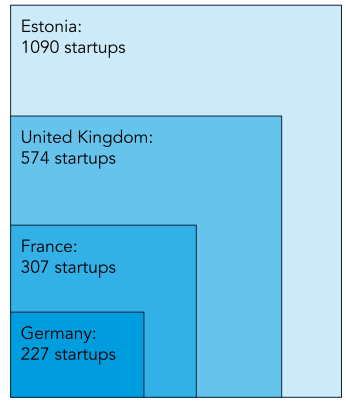
Potential economic impact for Bavaria

~11k Additional startups in Bavaria

180k New jobs in the startup economy

~3x Jobs indirectly created outside the startup economy

Startups per one million inhabitants



	1. Seamless company setup	2. Official forms available in English	3. Fast & accessible startup visas	Availability of a "one-stop-shop"
United States	◔	●	◑	◑
United Kingdom	◔	●	◑	◔
Estonia	●	●	●	●
Portugal	◑	◑	◔	◔
France	◑	◑	◔	◔
Abu Dhabi (UAE)	◔	●	●	●
Singapore	●	●	●	●
Germany	◑	◢	◑	◢
BayernBoost	●	●	●	●

Competition

- Estonia offers a fully online setup via the e-Business Register, which allows registration to be completed in hours [658]. Singapore enables incorporation in 1–3 days through BizFile+ [659], while the UAE provides digital registration in free zones [660].
- The UAE consolidates registration, licensing, and visas within free zones for a seamless process [660]. Estonia's e-Residency program acts as a single platform for company formation and management [661].
- Estonia's Startup Visa prioritizes scalability over upfront capital for visa applications [662]. The United Arab Emirates' five-year visa evaluates business potential instead of requiring pre-raised funds [663].
- Singapore and Estonia prioritize speed for entrepreneurship visa applications, processing them in 8 weeks [664] and 30 days [665], respectively.
- Despite not having English as the only primary language, the UAE, Estonia, and Singapore offer business registration and visa applications entirely in English, making them accessible to global entrepreneurs.

Other countries have already proven what is possible – Germany and Bavaria must act now to maintain a competitive edge on the global stage.

Roadmap

2025

API Infrastructure Paper

Launch an Infrastructure Paper for BayernBoost defining the technical standards, data fields, and API specifications required for digital company formation.

2026

Bavaria as a Regulatory Sandbox

Establish Bavaria as a regulatory sandbox to pilot company incorporation and completion of administrative tasks in English alongside AI-driven document verification to streamline processing.

2027

Platform Implementation and Launch

Develop and launch the technical platform, integrating key administrative workflows and using modular design to enable phased rollout and fast onboarding of partners.

2028

Policy for International Founders

Introduce policy packages for a capital-light, easy-to-obtain entrepreneurship visa based on business plans and English-language processes, ultimately integrating visa application into BayernBoost.

2030

Scaling of BayernBoost

Leverage results from the Bavarian pilot to advocate for national API standardization and national adoption, positioning BayernBoost as a scalable model for international founder mobility and digital-first governance.

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CRAW-O

Boosting Sovereignty via a Connected Circular Ecosystem for Key Raw Materials

The global landscape of critical raw materials (CRMs) presents a complex challenge for Germany's economic future and technological sovereignty. As our society advances toward green and digital transformations, the demand for materials like rare earths, lithium, cobalt, and graphite surges [666].

However, Germany heavily depends on imports of 34 critical raw materials [512]. Around 90% of critical raw materials are sourced outside the EU, with China dominating the global supply chain [667]. This concentration of supply creates significant vulnerabilities, particularly in light of increasing export restrictions and price volatility in international markets. Although the EU has introduced the Critical Raw Materials Act (CRMA) – requiring 10% of raw materials to be domestically extracted, 40% processed within the EU, 25% sourced from recycling, and limiting reliance on any single third country to 65% – a more innovative approach remains necessary [668].

Simultaneously, we are witnessing a mounting e-waste crisis. The Global E-waste Monitor 2024 reports that e-waste reached 62B kg in 2022, growing five times faster than recycling rates. This e-waste contains valuable minerals – approximately 12M kg of rare earth elements – yet only 22.3% is formally collected and properly recycled. In 2022, the e-waste generated contained metals worth an estimated 91B USD, yet only 28B USD worth was recovered [669]. While technological challenges play a role, the primary barriers to efficiently recovering valuable materials from e-waste are inadequate collection systems and limited financial incentives [670].

This intersection of critical material dependency and inadequate e-waste management represents both a challenge and an opportunity. The Critical RAW Materials Organization (CRAW-O) proposes a solution that addresses these dual concerns by establishing a comprehensive ecosystem for critical raw material recycling and innovation. By enabling startups through access to research grants and by connecting market participants, CRAW-O aims to reduce European dependency on foreign supplies. Thereby, it enables circular startups to connect with domestic production companies while ensuring economic competitiveness. Capturing the economic and environmental value currently lost through inadequate e-waste processing.

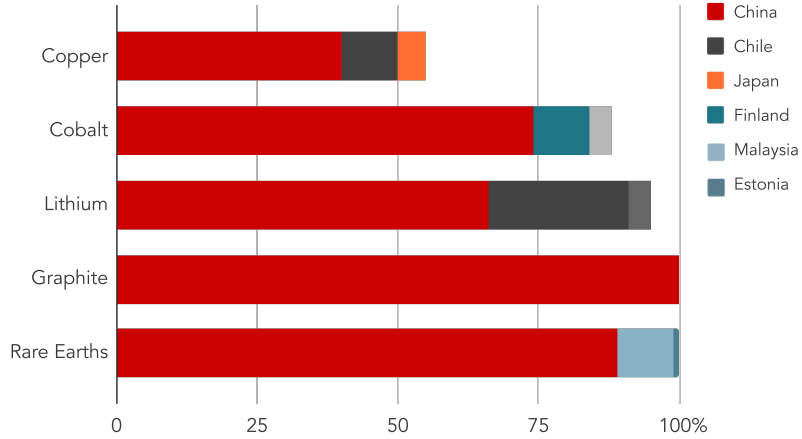
This collaborative approach not only fosters innovation but also promotes sustainable practices within the industry. By transforming e-waste into valuable resources, CRAW-O seeks to create a resilient supply chain that benefits both the environment and the economy.

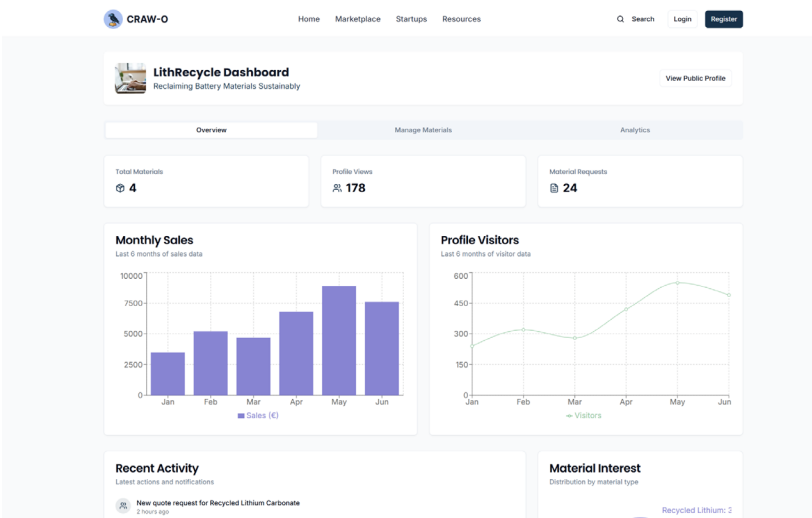
Problem

- The EU depends on external sources for 90% of its critical raw materials, with China controlling significant portions of global extraction and processing. This threatens Europe's and Germany's green and digital transitions through supply chain disruptions, price volatility, and geopolitical pressures [668, 667].
- E-waste recycling accounts for just 1% of the global demand for rare earth elements. With 1.5M truckloads of waste generated annually, Europe discards potential domestic resources while increasing import dependency [669].
- Lack of coordination in critical materials management prevents efficient circular value chains. Fragmentation in financial support, permitting procedures, and waste regulations creates barriers to innovative solutions [668].
- Without structured enablement, potential breakthroughs in critical material recovery remain unrealized, weakening Europe's resource security position.

Address Europe's 90% foreign dependency on critical materials by tapping into the 91B USD value hidden in our growing e-waste streams.

Countries leading the processing of critical raw materials





Solution

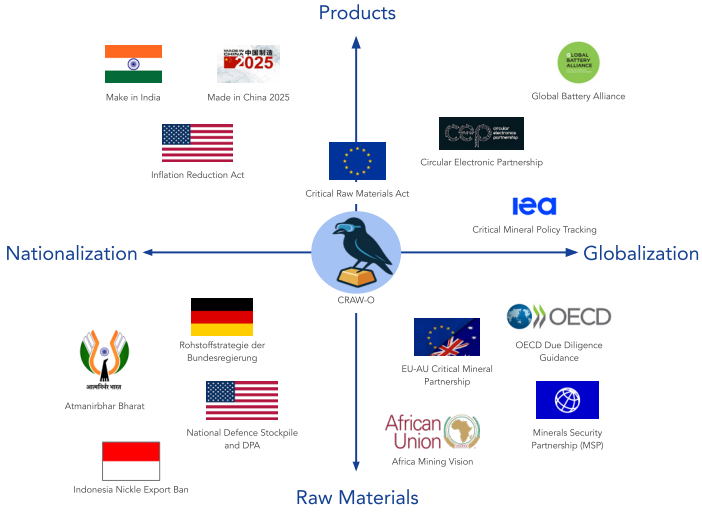
- CRAW-O addresses critical raw materials challenges through a comprehensive circular economy solution operating along two dimensions: structured funding and a connected marketplace.
- Modeled after Germany's SPRIN-D, CRAW-O provides grants, debt, and equity investments to recycling and circular economy startups, creating a pathway from research to market deployment for innovative technologies.
- On CRAW-O, companies can track and access German-made recycled materials, receive subsidies for choosing them over imports, and monitor growth metrics. This connects recycling startups with manufacturers seeking to reduce foreign dependency.
- Following successful examples from Japan's JOGMEC (32% dependency reduction) and South Korea's KPX (16% dependency reduction), CRAW-O creates both supply and demand-side incentives for a sustainable critical materials economy in Europe [667].

CRAW-O empowers businesses through its dual funding marketplace solution to access subsidized recycled materials and monitor performance.

Market

- The e-waste market represents a significant opportunity for CRAW-O's business model. Currently valued at 91B USD in recoverable metals alone, the global e-waste stream is projected to reach 82B kg by 2030. With only 22.3% of this waste adequately recycled worldwide, a substantial untapped market exists for improved resource recovery [669].
- European countries have the highest e-waste generation per capita globally (17.6 kg) and already lead in collection rates (42.8%) [669]. This existing infrastructure provides a foundation upon which CRAW-O can build.
- The market opportunity extends beyond simple material recovery. By leveraging the EU's Critical Raw Materials Act goals (10% domestic mining, 40% processing, and 25% recycling by 2030) [668], CRAW-O's marketplace can incentivize strategic recycling of critical raw materials to meet domestic demand.

Capture value in Europe's untapped 12-15B EUR critical materials market, where high e-waste generation meets low recycling rates of just.



Competition

- Instead of direct competition, CRAW-O would face several categories of adjacent market participants that could evolve into competitors or potential partners, such as circularity startups and resource-intensive production companies.
- For CRAW-O's marketplace to succeed, competing with global market prices of directly sourced minerals will be an ongoing challenge. For the grants program, state-backed initiatives in China, the US, Japan, and South Korea are likely to develop similar offerings.
- Tech giants like Apple and Samsung are investing in closed-loop material recovery for their products [671]. These vertically integrated systems could expand into broader marketplace offerings.
- Blockchain-based solutions like Minespider and Circulor currently focus on supply chain transparency but could leverage their technological infrastructure to develop transaction-based marketplaces for recovered materials.

Strategically partner with waste companies, tech giants, and traceability platforms to strengthen CRAW-O's unique dual-purpose ecosystem.

Roadmap

2025

Launch and Foundation

CRAW-O launches under EU frameworks as a public organization. Platform development begins, the core marketplace goes live, and 15–20 pilot startups are onboarded. Initial regulatory engagement and state funding are initiated.

2026

Early Growth and Regulatory Engagement

Platform expands with improved metrics dashboard. Deeper and more active collaboration with regulators begins to align incentives and standardize recycled material classifications.

2027

Scaling Operations

Marketplace scales to 50+ startups. Advanced analytics and certification standards are added. Revenue generation ramps up through fees and subscriptions.

2028

Break-Even and EU Integration

Break-even of operations is achieved. Strong regulatory ties established. EU-wide integration progresses, with preparations for international expansion.

2035

Full Impact and Financial Maturity

CRAW-O reaches its full operational growth and scale. Reducing the dependency of the EU upon critical raw materials by 20–25%. Annual revenues hit 120M–150M EUR, driven by diversified, sustainable income streams.

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PITCH

Bringing Startup Agility Into the Public Sector

Governments worldwide face the challenge of modernizing their digital infrastructure and services to match private sector quality standards [672] and catch up with digital leaders like Estonia, with 99% digitized administrative services [673]. Yet, traditional public procurement methods in Germany often overlook start-ups [674], who have become the drivers of today's digital advancement, offering agility, creativity, and cutting-edge solutions that frequently surpass incumbent vendors [675]. Excessive spending controls, burdensome procurement procedures, and long-term contracts with obsolete technology vendors prevent innovative firms from competing for government technology projects [676].

Public administrations are increasingly aware of their lack of access to innovators: they see that relying only on familiar big contractors can limit competition and slow the adoption of new technologies [677]. There is a growing consensus that fresh approaches are needed to tap into external innovation and accelerate digital transformation in the public sector [678].

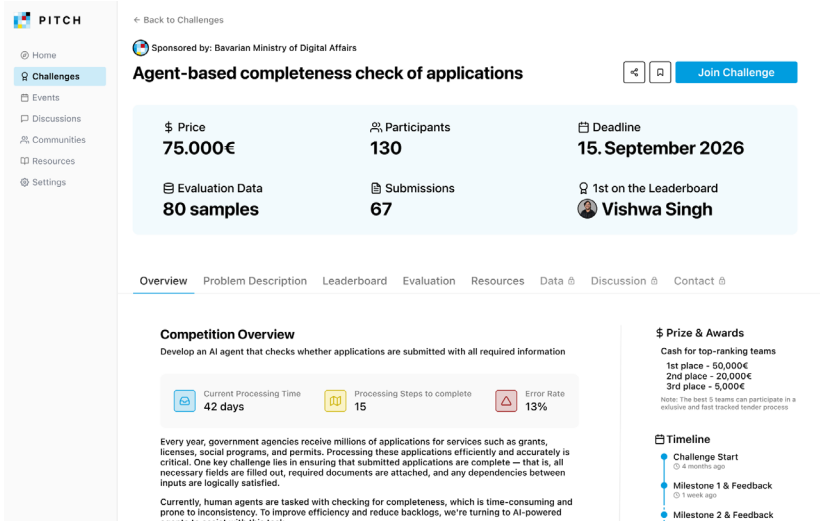
PITCH is designed to overcome the limited access to start-ups by reimagining how governments source digital solutions. It is a challenge-based platform where public administrations post specific problems and invite start-ups and tech teams across Europe to compete in developing the best solution. PITCH structures these competitions in multiple iteration loops, from prototype to final product, providing the conditions for agile development and open innovation principles. Governments can cast a wider net for ideas, quickly iterate to a production-ready solution, and foster an innovation ecosystem around them.

At the same time, start-ups get a fast-track route to deploy real solutions without wading through months of red tape and unclear requirements. The result is a win-win: ministries gain access to the best digital tools at start-up speed, and innovators collaborate directly with the public sector on their products. Crucially, PITCH also minimizes vendor lock-in by diversifying the supplier base and focusing on open, scalable solutions from the beginning. As increasing digitalization pressures create new openness among public administrators to innovative procurement methods [679], PITCH offers a forward-looking platform that helps governments become more experimental, accessible, and responsive in their technology procurement.

Problem

- In Germany, digital innovation in the public sector remains slow [680] for reasons such as high external dependency on digital service providers and products [681] and a lack of sufficient in-house technical talent [682], which is compounded by rigid procurement. This hinders fast decisions and clear communication of digital needs.
- Current public IT tender designs favor large incumbents and their consultant networks. They are prone to delays and cost overruns, with 80% exceeding schedules and tripling the likelihood of budget overruns compared to private sector projects [567].
- Startups are 50% less likely to win tenders [683] due to the operational burden of bidding, limited resources, and lack of exposure to the right contacts [684].
- Young companies are discouraged from co-developing with the public sector due to limited applicability for common product methodologies such as transparency, open data sharing, feedback, testing MVPs, and high user engagement [685].

Unlock public-sector innovation by replacing slow, startup-unfriendly tenders with faster, more agile procurement methods.



Solution

- PITCH serves as a platform where government entities can post technical challenges in simplified terms and with less bureaucracy than tendering to immediately reach a vast and active tech community.
- Each PITCH challenge provides problem documentation, process workflows, sample datasets, enabling participants to develop solutions immediately without bureaucratic blockers.
- PITCH challenges start with an open submission phase, followed by multiple elimination rounds of increasing duration. Top-performing participants or teams receive prize money at each stage and advance to further develop their prototypes into production-ready solutions, with the winning team securing the government contract.
- PITCH fosters a vibrant ecosystem around public innovation by connecting administrators, developers, and citizens through collaborative tools such as discussion threads and public leaderboards.

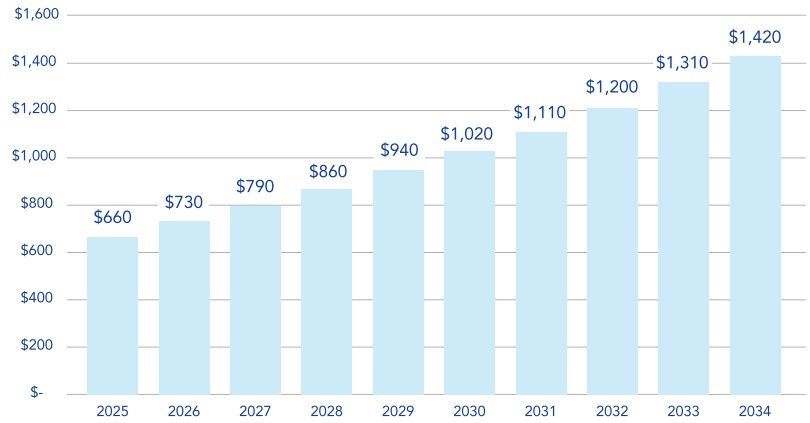
Adopt challenge-based procurement as the default interface for digital public problem-solving – fast, collaborative, and product-focused.

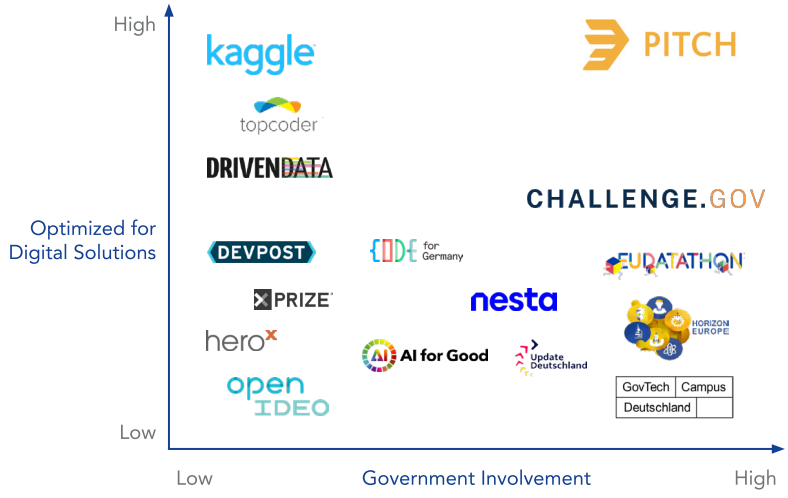
Market

- Global investment in digital transformation and AI is accelerating in the public and private sectors. The global GovTech market alone is projected to grow from 606B USD in 2024 to 1.4T USD by 2034 [686], underscoring the need to modernize how governments source and implement innovation.
- Currently, public procurement in the EU accounts for roughly 14% of GDP – around 2T EUR annually [687] – which means even minor improvements to how this money is deployed can have a significant impact.
- In Germany, over 44B EUR is planned to be invested in digital transformation efforts, including cloud, AI, and service modernization [688]. Even enabling 1% of this spend through challenge-based methods would unlock a 440M EUR opportunity to drive innovation with PITCH.
- International examples like Challenge.gov validate the potential. Through them, the US awarded over 173M USD in prizes in 2023 alone, attracting more than 6,000 participants, a 55% increase year over year [689].

PITCH improves how massive public procurement budgets are used in a rapidly growing digital, AI-enabled GovTech market.

Global GovTech market size, in $bn





Competition

- Collective problem-solving platforms span a range of industries and formats. They can be grouped according to their focus on digital challenges, how well they enable developers to work on digital solutions, and how much they are tailored to or driven by governments.
- Popular platforms like Kaggle or Topcoder have active communities but are limited to data or AI challenges that are often created primarily for learning purposes.
- Existing government initiatives like Challenge.gov or EU Datathon and offline programs like GovTech Campus each have limitations in technical focus, developer experience, or scalability.
- PITCH positions itself as a scalable platform for developer engagement and digital problem-solving, driven by real-world challenges and seamlessly integrated with the public sector.

PITCH offers multi-round development, feedback loops, and real contracts going far beyond existing solutions.

Roadmap

2025 — First Pilot Challenge

Launch an initial challenge under 100,000 EUR to test the complete PITCH iteration cycle using simplified procurement procedures. This validates legal feasibility and core assumptions

2025 — Platform Implementation

Develop a modular platform for posting challenges, managing submissions, facilitating feedback rounds, and awarding contracts.

2026 — Playbook Development

Create reusable templates and onboarding materials for government entities to independently implement challenges with scoping, feedback mechanisms, evaluation criteria, and procurement guidance.

2027 — Strategic Expansion

Expand to multiple ministries and municipalities while promoting interoperability and reuse of solutions between public bodies.

2028 — Model Institutionalization

Integrate challenge-based procurement into digital governance by advocating for supportive policies and establishing PITCH as a core GovTech tool for agile innovation.

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Workable

Workable

Engaging the Public Sector Workforce

The German public sector currently faces a significant engagement challenge, with 56% of civil servants feeling insufficiently recognized for their work [690]. Rigid hierarchies, reluctant forwarding of responsibilities toward lower hierarchy levels, and complex communication structures hamper employee motivation within the public sector [691]. Furthermore, only few public sector employees receive long-term career development guidance [690].

The presence of a disengaged workforce constitutes a notable challenge for the public sector. In fact, low employee engagement and happiness can decrease productivity and increase absenteeism [692, 693], and the public sector in Germany is already characterized by an excessive amount of sick days compared to the private sector [694].

Incorporating an Employee Experience Platform (EXP) in the public sector could significantly enhance workforce engagement. EXPs are Human Resources tools that improve communication and productivity in the workplace, increase employee retention, personalize employee experience, and improve workplace culture [695]. The success of EXPs has already been demonstrated in the private sector: Adobe's Check-In system reformed how performance reviews are done, transitioning from annual to continuous feedback. The system has proven to rapidly increase employee engagement and reduce voluntary turnover by 30% within the first year [696, 697]. Other well-known corporates, like Microsoft and Accenture, have since imitated Adobe's Check-In system [696].

To increase employee engagement in the public sector, continuous check-in systems should be transferred from the private to the public sector. In this sense, we propose Workable – an EXP designed to empower the public sector.

Workable facilitates structured, regular feedback conversations, cultivating an environment where feedback is valued. It enhances individual career development by encouraging employees and managers to set and monitor goals together.

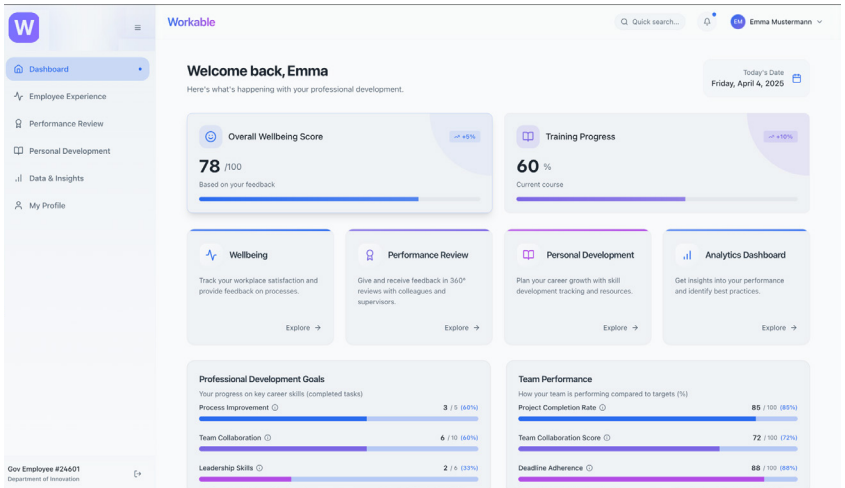
The Workable platform also measures employee satisfaction, enabling managers to identify concerns early and enable proactive and timely interventions.

Adopting Workable in public administration can lead to a more engaged, capable, and satisfied workforce, ultimately improving the efficiency and effectiveness of government services.

Problem

- Organizations with highly engaged workforces experience a 17% increase in productivity compared to organizations with less engagement. Furthermore, employees who are very motivated tend to experience better overall well-being and, on average, remain with the company longer [698].
- A study conducted by the Federal Ministry of the Interior and Community found that 56% of surveyed German civil servants feel that they do not receive sufficient recognition in their work environment. In comparison, only 20% receive personal career development support [690].
- Civil servants in German ministries and government agencies report an average of 21.7 sick days per year, which is significantly higher than the national average of 15.1 days [699].

The German public sector urgently needs to address cultural work issues like insufficient recognition, career stagnation, and low productivity.



Solution

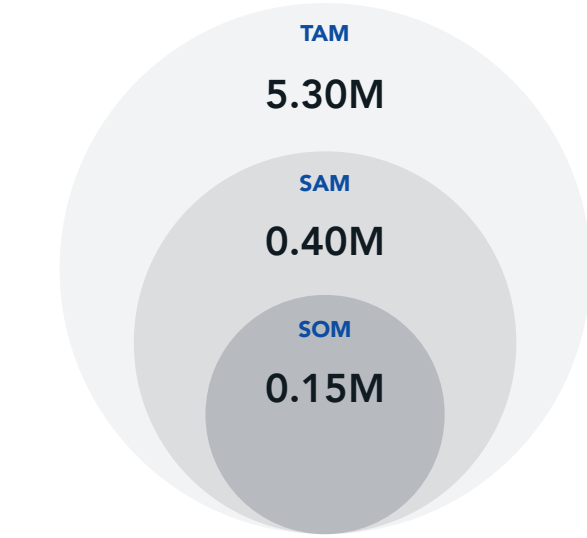
- Managers can collect regular feedback using anonymous pulse surveys tailored to their departments and current projects. Moreover, 360-degree feedback processes allow employees to give and gather input from colleagues and supervisors, replacing infrequent and informal review discussions.
- Employee performance can be monitored using tools for monthly check-in tracking, collaborative and transparent goal and progress setting, and concrete skill development plans and targets.
- Real-time data dashboards visualize sentiment trends, learning activity, and top team concerns. The insights allow managers to act proactively with role- or team-specific interventions, increasing transparency and accountability in employee engagement and drawing attention to prevailing issues.

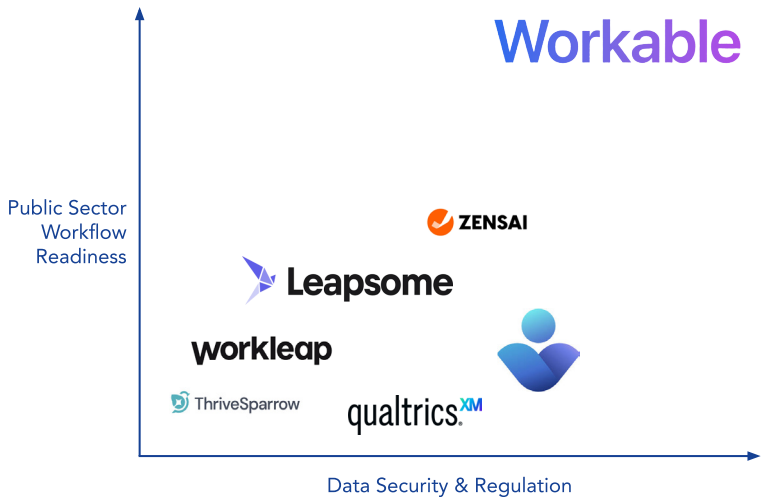
It is not about more HR processes. It is about empowering public servants to feel seen, heard, and supported in doing meaningful work.

Market

- At the outset, Bavaria's core state administration, comprising about 158,000 ministerial staff and state authorities, could benefit directly from the platform [699].
- The overall Bavarian public sector employs around 404,000 workers. Workable can be rolled out to all of Bavaria's public sector after the first successful experiences with the core state administration.
- In the long run, Workable can serve the entire German public sector, comprising over 5.3M workers [700].
- Workable offers significant saving potential for the public sector. In 2023, personnel costs accounted for 8.7% of the 476B EUR federal budget [701, 702]. By increasing employee engagement, as Workable aims to do, absenteeism can be reduced [703]. For every day of average absenteeism reduced by Workable, expenditures in the hundreds of millions can be saved yearly. These savings are supplemented by productivity increases and lower employee turnover rates.

Workable can impact the engagement of 158,000 employees in Bavaria. Taken to the state level, it could reap savings in the hundreds of millions.





Competition

- Employee Experience (EX) platforms are used in the private sector, with providers offering solutions across industries and company sizes [704]. Platforms like Culture Amp and 15Five offer solutions for agile team structures, self-directed career progression, and minimal compliance overhead.
- However, public institutions operate under different conditions, including stricter data compliance, auditable engagement workflows involving external stakeholders such as worker unions, and long-term development tied to tenure-based career structures [705].
- Workable is explicitly built for the realities of the public sector, with data handling that ensures regulatory compliance. These multi-stakeholder engagement processes ensure verifiability and support for long-term tenure-based development. On top of that, by aligning natively with public workflows, it avoids costly customizations and enables a scalable rollout.

Workable is built for the public sector and its unique requirements, offering tailored solutions that set it apart from private market alternatives.

Roadmap

2025

Assess Status Quo

Comprehensive assessment of existing feedback and performance review processes at the ministry and municipal level to identify the biggest inefficiencies, pain points, and areas for improving employee experience and team culture support.

2026

Define Goals

Organize workshops with department heads, HR personnel, IT staff, and employee representatives to define clear goals and success measures, ensuring alignment with governmental policies, data protection regulations, and ministry initiatives.

2027

Develop the EXP

Design, develop, and build pilot features through an iterative process, ensuring the platform meets user requirements, government security standards, and data protection laws.

2028

Pilot Launch within the Digital Ministry

Evaluate the platform's effectiveness, user adoption, and employee reception in a controlled environment while providing training to users and encouraging active feedback to optimize functionalities.

2030

Statewide Implementation Strategy

Discuss and align with municipalities on broader deployment across the state, deriving a concrete implementation plan, including timelines, resource allocation, and training programs for new users.

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Baize

Baize

Simulating Climate Futures to Build Resilient Infrastructure

Climate change increasingly threatens urban infrastructure, with severe weather events becoming more frequent and intense. In Germany alone, climate change already costs at least 6.6B EUR annually, with catastrophic events like the Ahrtal floods causing 40B EUR in damage. Municipalities are under growing pressure to protect citizens and assets as future extreme weather scenarios are expected to escalate. [706]

Recent advances in weather modeling, geospatial data, drone surveillance, and digital twin technology now allow precise infrastructure-level simulations, creating new opportunities to build resilience proactively.

Baize is a simulation platform designed to help urban planners in municipalities enhance climate resilience by analyzing the impact of extreme weather scenarios on municipal infrastructure. It combines state-of-the-art AI-driven climate simulations and weather models with infrastructure data to simulate extreme weather events like floods, storms, heatwaves, and droughts. Baize thereby generates localized insights for urban protection measures and city planning. The platform integrates diverse data sources, including satellites, drones, digital twin datasets, specialized weather data, and municipal land registries. By analyzing how natural systems, like rivers, interact with their environment during heavy rainfall, Baize can predict risk on specific buildings and infrastructure.

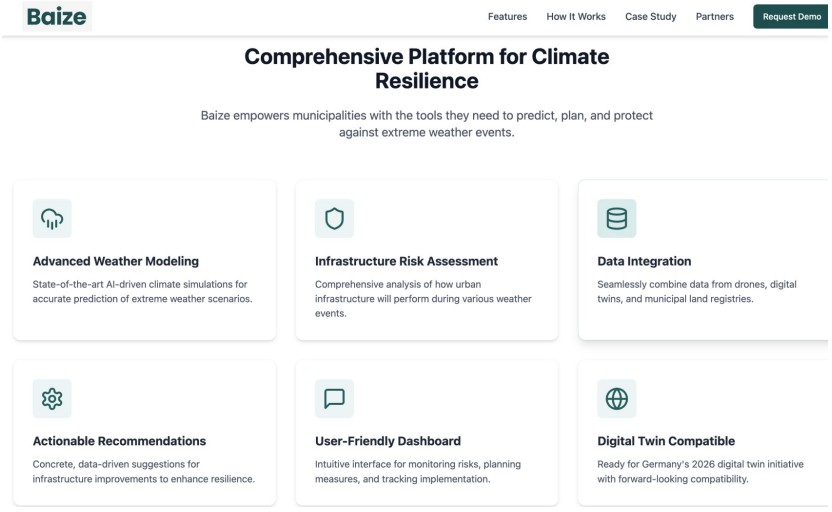
The core value of Baize lies in its ability to not only simulate extreme weather scenarios but also provide concrete, data-driven recommendations like flood barriers or drainage system enhancement to minimize risks. The platform's user-friendly dashboard allows municipalities to monitor risks continuously, plan proactively, and prioritize investments in resilient infrastructure. By delivering tailored insights and actionable guidance, Baize helps municipalities make informed decisions to protect both lives and assets. Partnering with municipalities, universities, insurance companies, simulation model developers, and construction professionals ensures that recommendations are research-driven and practical.

Baize will showcase its potential by running proof-of-concept simulations of the Ahrtal catastrophe, demonstrating how it could have identified risks and suggested measures. It will then onboard pilot municipalities, becoming a key partner for climate resilience before Germany's digital twin launch in 2026.

Problem

- Climate change is leading to more frequent and severe weather events, damaging infrastructure, costing human lives [707, 708], and driving the demand for resilient infrastructure solutions [709]. It costs Germany at least 6.6B EUR annually [710], is expected to reduce Germany's GDP by up to 0.35% per year, and causes welfare losses of up to 0.36% annually by 2050 (depending on climatic and socio-economic factors) [711].
- In Germany, information is scattered across multiple websites maintained by various agencies, research institutes, NGOs, and think tanks. Even though there are efforts to provide a one-stop shop with the ZKA (Centre for Climate Adaptation), information access and user experience need to improve [506].
- Germany is a key hub for transportation, commerce, and defense for Europe, with climate disruptions potentially having far-reaching impacts on European stability [712].

Germany must invest in resilient infrastructure to protect its economy, security, and society from increasing climate risks.



Solution

- Baize combines accurate weather data with digital twins and other infrastructure and geodata to simulate future extreme weather impacts accurately on a building-by-building level. It uses AI-driven predictive models to precisely forecast infrastructure damage from floods, heatwaves, storms, and droughts for municipalities.
- Baize provides an overview of targeted resilience measures like flood barriers, backflow valves, and heat-resistant materials with detailed risk reduction estimates and provides insights for planning new city infrastructure projects.
- The platform delivers a cost-benefit analysis for each adaptation measure and can highlight potential subsidies, insurance incentives, and resilience loans to support proactive investment.
- It offers an intuitive interface for municipalities to simulate climate risks, identify impactful adaptation measures, and plan long-term urban resilience strategies.

Baize's climate simulation platform empowers municipalities to identify, evaluate, and implement the most impactful resilience measures.

Market

- In Germany, 80 cities with a population of over 100,000, representing 32% [713] of the national population, have a budget of approximately 1.2B EUR on climate adaptation projects, with municipalities typically investing around 250,000 EUR [629] per project.
- Across all 11,000 German municipalities [714] annual climate-related spending is estimated at 3.9B EUR, including 2.9B EUR for climate protection and 1B EUR for climate adaptation and a national emergency support program allocating 60M EUR until 2026 [715].
- Municipalities worldwide that face extreme weather risks, particularly in high-risk regions such as the Asia-Pacific region, require an estimated amount of 9.2B USD for planning and knowledge, with a projected global average of 7B USD annually from 2015 to 2050 [716].
- Investing in disaster risk reduction yields a fourfold return on investment [717].

Invest in climate resilience now – every euro spent on risk reduction saves four euros. Secure funding and protect your community with Baize!

SIGNIFICANT SAVINGS POTENTIAL WITH CLIMATE FOCUSED INVESTMENTS

Cost savings ratio 1:4

Benefits of disaster risk reduction on investments

3.1B EUR

Financing initiative from UN to support high-risk cities that require additional financing

PROJECTED ANNUAL SAVINGS

Cities under risk supported by Germany

40B EUR

Projected annual savings for Asia-Pacific cities under risk financed by UN contributions

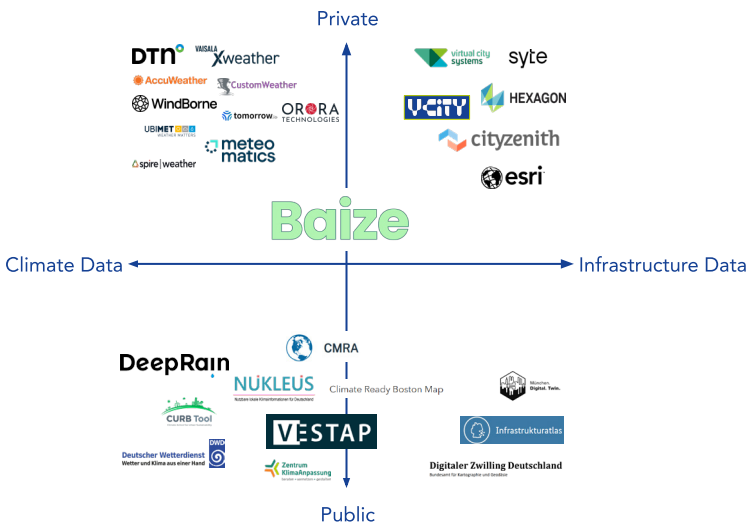
All of Germany

16B EUR

Projected annual savings for Germany's climate risk investments

80 municipalities in Germany

80M EUR



Competition

- Germany's fragmented approach to climate adaptation across government levels hinders effective extreme weather risk prevention even though publicly funded tools and communities for coordination exist [718].
- International tools like CMRA [719] or VESTAP [720] focus on region-specific climate vulnerability assessments integrating federal data to enable communities in resilience planning and climate adaptation prioritization.
- Weather simulation providers like DTN [721], tomorrow.io [722], Orora Technologies [723], and infrastructure analysis tools like syte [724], or digital twin developers such as virtual city systems [725] and Hexagon [726] provide business insights and support urban planning. However, these solutions operate in fragmented data silos and lack the building-level detail that municipalities need to derive actionable insights from climate and extreme weather risk simulations.

Amid fragmented climate analytics and digital twin competitors, Baize uniquely delivers actionable infrastructure resilience solutions.

Roadmap

2025

Strategic Municipality Partnerships

Demonstrate the value of Baize in local planning by offering pilot projects and showcasing proof-of-concept based on the Ahrtal catastrophe with digital twins.

2026

Policy Advocacy

Lobby for a mandate to have climate resilience simulations as part of municipal planning, funded by the 100B EUR Climate and Transformation Fund (KTF), and engage with climate-focused think tanks to gain support.

2027

Utilize the German Digital Twin

Access national 3D models and datasets as soon as they become available and lobby for them to be made accessible not only to federal authorities but also to innovative companies.

2028

Opportunities Outside of Germany

Focus on regions where all necessary data components for simulations and risk assessments are already available.

2029

Insurance Company Partnerships

Advocate for policy frameworks that incentivize lower insurance premiums for municipalities utilizing digital twin-based climate resilience tools.

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Publisher Center for Digital Technology and Management
Arcisstr. 21
80333 Munich, Germany

E-Mail: info@cdtm.com
www.cdtm.com

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With support from the entire Class Spring 2025

Printed Copies 40

Printing Company printworld.com GmbH
Weststraße 60
09603 Großschirma

Photos https://unsplash.com/
https://www.stock.adobe.com/de/
https://www.gettyimages.de/
https://www.flaticon.com/

Year of Publication 2025

THE FUTURE OF POLICY-ENABLED INNOVATION

Europe stands at a pivotal crossroad: Productivity is stagnating, inequality is rising, and demographic shifts are widening. Moreover, democratic values are increasingly being questioned, and Germany seems too paralyzed by its bureaucracy to respond adequately. At the same time, we have unprecedented rates of technological and economic growth, posing systematic opportunities for transformation and development. To strategically leverage these opportunities as drivers for meaningful change, we need policymakers to effectively enable innovation.

Looking back, well-crafted policies have catalyzed major innovation leaps such as the invention of the internet, bluetooth, satellite navigation, and the development of mRNA vaccines that made the rapid development of COVID-19 vaccines possible, saving millions of lives.

Accelerating developments pose uncertainty across all dimensions, with questions such as: What technologies will shape our daily lives in the coming years? How can we unlock AI's potential to streamline public services? Are we over-regulating new technologies? Or do we underestimate the potential of technological transformation? What role can circular economy models play in achieving climate goals and ensuring the sovereignty of our supply chains? And crucially, how can Germany and Europe position themselves as magnets for global top talents and investments?

This report repositions policy as the key lever to navigate the world's growing uncertainty. Policies can enable progress that our society needs, to iteratively find answers and turn chaos into structure. It organizes these considerations into three sections: trends, exploration, and ideation.

The introductory section outlines trends in technical, societal, environmental, legal, and economic areas to provide a clearer picture of expected developments in the coming years. Further, selected problem spaces outline specific challenges related to government efficiency, external dependencies, infrastructure, workforce, and overall Germany's innovation ecosystem. Finally, the report presents a set of tangible ideas to inspire policymakers toward action.

With strategic foresight, regulatory agility, and collaborative ecosystems, policymakers can shape the conditions for Europe to thrive despite growing complexity. Citizens, businesses, and policymakers need to work closely together and collectively leverage and convert our pivotal crossroad into an unprecedented opportunity for innovation.

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The Center for Digital Technology and Management (CDTM) is a joint interdisciplinary institution of education, research, and entrepreneurship of the Ludwig Maximilian University (LMU) and the Technical University of Munich (TUM).

CDTM offers the interdisciplinary add-on study program "Technology Management". Students from various study backgrounds with creative ideas, great motivation and an entrepreneurial mindset are offered the tools to put their ideas into practice. As a research institution, CDTM closely cooperates with the industry, startups and the public sector concentrating on topics at the intersection of technology, innovation, and entrepreneurship.

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