

Mapping Lower Saxony's Competitiveness and Investment Priorities in Key Strategic Technologies

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Executive Summary

With rapid technological disruption and raising global competition, the prosperity of European regions increasingly depends on their ability to lead in strategic technology domains. Each region presents a unique mix of specialisations and capabilities, which in turn provide the foundations for a tailor-made path to industrial and technological development. In view of this peculiarity, which economists have come to acknowledge and nurture in their studies on complex systems and innovation, public decisionmakers, universities and regional business leaders should devote time and resources to understanding what possibility frontier their territory features, and take appropriate measures to ensure that the region's unique potential is properly unleashed, avoiding the imposition of non-autochthonous models.

This CEPS report focuses on Lower Saxony, and presents a comprehensive, data-driven assessment of the region's competitive standing in 39 Key Strategic Technologies (KSTs), which are deemed to be crucial future prosperity, economic resilience, and national security. The report maps the region's local innovation ecosystem, and identifies its position within a broader inter-regional network.

The data-driven insights presented in the report are based on three major datasets covering 2010–2025: scientific publications, patent documents, and investment data. The findings demonstrate that Lower Saxony possesses a distinctive innovation profile rooted in industrial depth, strong scientific capacity in selected disciplines and emerging strengths especially in climate-related technologies, while also revealing structural limitations related to digital innovation, venture-capital availability, and alignment between science and technology.

Key Highlights

Lower Saxony's innovation ecosystem is anchored in strong industrial capabilities, particularly in **mobility, manufacturing and energy technologies**.

Patent data show that **the region remains a national leader in technologies linked to autonomous and connected mobility, propulsion systems, advanced manufacturing processes, industrial automation and energy systems**. These strengths are complemented by substantial scientific output in engineering and computer science, although the degree of overlap between scientific and technological strengths varies by domain.

In the climate and green-technology domains, evidence highlights **strong performance in sustainability-oriented fields**. Lower Saxony demonstrates meaningful scientific and technological capabilities in **carbon-neutral production methods, flexible energy systems, water purification and other climate-technology areas**, reflecting a regional commitment to supporting the energy transition.

However, the region's performance is **less pronounced in frontier climate technologies such as fusion, advanced renewable-energy systems and carbon-capture technologies**, where specialisation remains limited relative to leading regions. This indicates that while the region contributes meaningfully to several sustainability-oriented technologies, it would benefit from greater investment and strategic emphasis in frontier areas that are gaining prominence in European and global innovation systems.

The **life science and health domain** presents a differentiated picture. Lower Saxony exhibits **strong specialisation in medical technologies, biophotonics and health-related imaging technologies**, supported by significant scientific output and a robust knowledge base in medicine and life sciences. Evidence from patents confirms these strengths, with notable activity in **medical devices and diagnostics**. However, the region shows relatively **modest specialisation in biotechnology and pharmaceuticals compared to other German regions**. This is due to the fact that existing scientific strengths in these areas do not consistently translate into technological outputs or investment activity, suggesting the presence of structural gaps within the life-science innovation chain. This uneven distribution implies the need for targeted policies to support translational research and to strengthen connections between academic research, industry and clinical institutions.

The **digital technology landscape reveals some of the most pronounced gaps**. Although Lower Saxony's universities and research institutes publish extensively in artificial intelligence, robotics, data science and automation, the region exhibits relatively **weaker technological specialisation in digital frontier technologies such as cyber security, immersive technologies, semiconductors and quantum technologies**. The evidence suggests that the translation of digital scientific strengths into technological innovation is incomplete, with limited venture-capital investment further hindering the development of a robust digital-technology ecosystem. As a result, **digital strengths in Lower Saxony remain largely embedded in applied contexts linked to manufacturing, mobility and agriculture**, with limited emergence of a standalone digital-innovation sector. This gap represents one of the region's most significant strategic vulnerabilities, particularly given the increasing centrality of digital-general-purpose technologies in shaping industrial competitiveness.

The region's collaboration patterns further contextualise these findings. In scientific collaborations, Lower Saxony maintains strong connections with Berlin, Cologne, Munich, Saxony-Anhalt, Thuringia and other German regions, with international collaborations emerging in selected domains such as photonics, robotics, semiconductor technologies, space mobility and selected climate-technology fields. However, **overall international collaboration intensity remains modest relative to national collaboration patterns**. A similar pattern emerges in technological collaboration, where patent co-inventorship networks predominantly involve other German regions, with limited cross-border technological partnerships. These

collaboration patterns reflect **an innovation system that is well-integrated nationally but less internationally connected**, potentially restricting its ability to absorb global technological developments.

Data on startup investment highlights a notable **under-development of venture-capital funding** in Lower Saxony. The volume of private investment is comparatively low, and the region exhibits fewer high-growth technology startups than major German innovation hubs. The evidence suggests that while industrial actors play a significant role in technological development, the **startup ecosystem remains limited in scale and scope**, with underdeveloped financial infrastructure and insufficient access to risk capital hindering the emergence of new technology-based firms. This limitation is particularly pronounced in digital, biotech, quantum and advanced-materials domains, where early-stage companies require substantial investment to scale. The **scarcity of specialised venture-capital funds presents a structural bottleneck** that reduces the region's ability to translate scientific research into commercial innovation.

Strategic Recommendations

- R1. **Double down in those domains where the region already demonstrates strong and mutually reinforcing scientific and technological specialisation**, particularly in autonomous and connected mobility, smart factories, and automation and robotics. In these areas, the evidence shows that the region combines a dense industrial base, significant patenting activity, and a solid research landscape, implying high “return on coordination” from targeted policy intervention. Regional policy should treat these domains as **“optimal investment domains,”** focusing support on scaling up existing strengths. This entails strengthening long-term R&D partnerships between major industrial players and key universities and research institutes, investing in dedicated test beds and demonstrator facilities, and ensuring that these domains are systematically prioritised in regional innovation strategies, skills programmes, and infrastructure planning. If properly supported, autonomous and connected mobility, smart factories, and robotics can continue to function as anchor domains around which other technological activities and supply chains can coalesce, reinforcing Lower Saxony's role as a leading industrial and mobility hub.
- R2. **Bridging domains where Lower Saxony has a strong research base and high potential economic impact but has not yet translated these strengths into fully fledged technological or industrial specialisations.** This particularly applies to semiconductors and microchips, artificial intelligence and big data, and quantum technologies. These fields can be considered **“moonshot”** domains in which global competition is intense but where even regional footholds can unlock significant long-term economic and strategic benefits. Policy should therefore support ambitious, mission-like initiatives that bring together universities, research institutes, large firms and emerging deep tech startups in these areas. This may involve establishing regional competence centres in semiconductors and microelectronics with explicit links to automotive, energy and industrial applications; creating flagship AI and big data programmes that connect methodological excellence to concrete industrial challenges; and backing quantum-technology pilots focused on sensing, communications and secure data systems relevant to regional industries. Such

moonshot initiatives should be underpinned by multi-annual funding, strong governance structures, and systematic integration into European and national technology programmes, so that Lower Saxony is not merely a passive adopter of frontier technologies but an active contributor to their development and deployment.

- R3. Narrow the research-innovation gap.** Across many of these domains, the analysis reveals a **structural gap between research excellence and technological excellence**, pointing to persistent weaknesses in translation and commercialisation. In several KST fields, Lower Saxony's universities and research institutes produce high volumes of high-quality scientific output, but this does not consistently translate into patents, technology platforms or scalable firms. Policy should therefore focus on narrowing this research–technology gap through targeted instruments that incentivise university–industry partnerships, proof-of-concept development, and innovation acceleration. Priority could go to the creation or expansion of translational funding schemes that specifically support the maturation of research results into demonstrators and prototypes; the establishment of joint industrial labs where doctoral candidates and postdocs work directly on co-defined problems; and the development of sector-focused accelerators that provide technical, regulatory and business support for teams spinning off from universities. Attention should also be paid to incentives and recognition mechanisms within the academic system so that engagement in applied research, patenting and collaborative projects is institutionally valued, and not perceived as a deviation from academic excellence.
- R4. Strengthen the local startup ecosystem.** The current investment landscape shows that biotech and medtech startups dominate the existing venture activity in Lower Saxony, which reveals an underlying imbalance: despite significant technological and scientific capabilities in domains such as robotics, automation, AI and advanced manufacturing, startups in these areas attract far less funding. This asymmetry suggests that high-potential deep tech opportunities remain underexploited. Policy should therefore create more favourable conditions for the emergence and growth of startups in non-life-science deep tech domains. This requires improving access to entrepreneurial training and mentoring for engineers and computer scientists, strengthening incubators and accelerators that are specialised in industrial and digital technologies, and ensuring that public procurement, pilot projects and test fields are accessible to young firms rather than being dominated by established incumbents. It also implies facilitating the integration of startups into existing industrial value chains, for example through structured supplier-innovation programmes or challenge-driven innovation calls where large firms and public bodies articulate concrete needs that startups can address.
- R5. Improve the funding environment.** This is a critical enabling condition for all of the above. While targeted public grants are important, they are not sufficient on their own to support the type of deep tech innovation that characterises advanced industrial, digital and climate technologies. Regional policy should therefore aim to expand both the volume and sophistication of early-stage risk capital available in Lower Saxony. This can be done through a blend of instruments. On the public side, the region can develop or enlarge dedicated deep tech seed funds and co-investment vehicles that reduce the risk borne by private investors in early stages, particularly in capital-intensive domains such as

semiconductors, robotics and quantum. On the private side, there is a clear opportunity to leverage large industrial firms active in the region by encouraging the creation and scaling-up of corporate venture-capital arms. Corporate venture capital linked to automotive, energy, agrifood and industrial groups can play a decisive role in financing and validating new technologies, while embedding startups into global value chains.

R6. Make public–private co-investment a central pillar of Lower Saxony’s innovation strategy.

Blended public-private investment can combine regional development finance, national and European funding instruments, and private capital from institutional investors and corporates, with professional fund management and clear performance metrics. The design of such funds should ensure that they are able to invest not only in software and business-model innovation but also in hardware-intensive and deep tech startups, where development cycles are longer and risk profiles more complex. Complementary to equity instruments, targeted innovation loans and guarantees can help more mature SMEs invest in the adoption and deployment of new technologies developed within the region. Entities like SPRIND in Germany and the European Innovation Council, with its future ARPA-style programmes, can be very important partners in this endeavour. Partnerships with European and international financial institutions can also trigger deeper internationalisation and more global research collaboration.

R7. Strengthen digital innovation capabilities through targeted investment in digital infrastructure, specialised test beds, talent development programmes and scale-up mechanisms for digital startups. This requires a specific policy mix made of dedicated access to digital infrastructure, an in-depth analysis of the impact of digital technologies on business model reorganisation in specific domains, and an ambitious skills upgrade, retention and attraction policy. Recent policy strategies introduced at the EU level, particularly the Apply AI strategy and the prospective reform of Horizon Europe post-2028, could provide very important opportunities in this respect, also due to the emphasis on completing the ecosystem in specific domains, and involving private actors and philanthropies in the selection and funding of R&I projects, and more direct link to scale-up and innovation diffusion in specific industry verticals constitute an opportunity that Lower Saxony should seize in the coming years. This, in turn, warrants a more attentive and proactive presence of representatives of the Lower Saxony ecosystem in Brussels.

Taken together, these recommendations suggest **a three-layered policy approach**. At the core, Lower Saxony should consolidate and deepen its leadership in autonomous and connected mobility, smart factories, and automation and robotics, treating these as strategic domains that anchor its industrial identity. Around this core, the region should build ambitious bridging initiatives in semiconductors, AI and big data, and quantum technologies, ensuring that strong research bases are translated into technological and economic advantages through mission-like programmes. Enveloping both, the region should develop a more robust translational and entrepreneurial infrastructure, including university–industry interfaces, accelerators and a significantly strengthened venture-capital environment, with special attention to non-biotech deep tech startups and to public–private co-investment mechanisms. By pursuing this integrated strategy, Lower Saxony can both secure its existing comparative advantages and open new pathways for long-term, innovation-driven growth.

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Introduction: a Resilient Region that Faces New Challenges

Lower Saxony (*Niedersachsen*) is Germany's second-largest state by area and fourth-largest by economic output. Its GDP—[approximately](#) €380 billion in 2024—derives from **a distinctive combination of manufacturing, agriculture, logistics, and energy production**. Historically reliant on the automotive industry, the state has diversified through investment in renewable energy, port logistics, and advanced materials. Industrial geography confers unique strengths: Wolfsburg, Emden, Osnabrück, and Salzgitter form the automotive heartland; Hannover and Stade anchor aerospace and maintenance clusters; Wilhelmshaven, Cuxhaven, and Emden serve as deep-sea ports and energy terminals; and Weser-Ems remains a dominant agricultural zone.

In terms of macroeconomic performance, as reported by the *Landesamt für Statistik Niedersachsen* (LSN, [2025b](#)), **Lower Saxony's real GDP grew by 0.4 per cent in 2024, outperforming Germany's national average of -0.2 per cent**. In the first half of 2025, output expanded by 1.0 per cent year-on-year, while nominal GDP rose 3.8 per cent ([LSN, 2025c](#)). Agriculture, forestry, and fisheries increased value added by 2.6 per cent, while manufacturing recovered from supply-chain constraints. **Growth drivers in 2024 included energy production, port throughput, and selected manufacturing exports**. However, business climate indices compiled by the Industrie- und Handelskammern (IHK, 2024) remained subdued, reflecting high input costs and regulatory uncertainty.



Employment averaged 4.2 million persons in 2024, an increase of 0.1 per cent over 2023 ([LSN, 2025d](#)). Unemployment remained around 5.1 per cent, yet structural challenges persist in training and labour mobility. The demographic profile—ageing and modest net migration—suggests **tightening labour supply by the late 2020s** (NORD/LB Research, 2025).

Municipal accounts remain under pressure. The Landesrechnungshof Niedersachsen ([2024](#)) described a “financial permanent crisis,” citing high debt and deferred investment in education

and transport infrastructure. Fiscal limitations also risk constraining co-funding for federally or EU-backed projects, a recurring issue in industrial and climate programmes ([Welt, 2025](#)).

Lower Saxony's economy continues to revolve around the automotive sector, dominated by Volkswagen AG and its suppliers. The Wolfsburg headquarters and main plant employ roughly 60,000 people. In 2024–2025 Volkswagen implemented a restructuring pact—guaranteeing jobs until 2030 while preparing for a potential four-day week to manage the shift to electric models ([Reuters, 2025](#)). The Emden facility, fully converted to electric-vehicle production (ID.4 and successors), assembled approximately 180,000 units in 2024. Osnabrück, responsible for niche models such as the T-Roc, anticipates phase-out by 2027 (Reuters, 2024). Supplier firms in Salzgitter and Braunschweig increasingly specialise in battery systems, power electronics, and e-mobility components. Despite transformation costs, automotive exports remain substantial. Ports at Emden, Cuxhaven, and Wilhelmshaven handled about 1.65 million vehicles in 2024 ([Seaports of Niedersachsen, 2025](#)).

Aerospace manufacturing forms the state's second major specialisation. Airbus Stade, a global centre for carbon-fibre composites, expanded in 2024 with its ZEROe Development Centre focusing on hydrogen-fuel technologies ([Airbus, 2024](#)). The site's R&D capability positions it at the forefront of aviation decarbonisation. Meanwhile, MTU Maintenance Hannover—employing about 2,500 specialists—remains Europe's largest engine-maintenance facility for wide-body aircraft, handling roughly 400 shop visits per year ([MTU Aero Engines, 2024](#)). These aerospace activities generate high-skilled employment and technological spill-overs, supported by clusters such as CFK-Valley Stade and the Centre for Applied Aeronautical Research.

Lower Saxony leads Germany in **renewable generation**. In 2024, 673 MW of new onshore wind capacity was installed—the second-highest increase nationwide ([Fachagentur Wind und Solar, 2025](#)). Total onshore capacity exceeded 13 GW by year-end. Offshore, approximately 5.3 GW of Germany's connected capacity feeds through Lower Saxony's grid nodes ([BWO, 2024](#)). Federal auctions in 2025 added further projects in the Nordlicht cluster.

The JadeWeserPort Wilhelmshaven, Germany's only deep-water container terminal, recorded 843,000 TEU in 2024 and surpassed 1 million TEU in mid-2025 ([Seaports of Niedersachsen, 2025](#)). Upgrades include automated cranes and hinterland rail links. The ports of Cuxhaven and Emden support automotive and offshore wind logistics. Collectively, Lower Saxony's seaports handled over 50 million tonnes of goods in 2024, up 6 per cent year-on-year.

Another important domain in the economy of Lower Saxony is **hydrogen and gas**. The Wilhelmshaven 2 LNG terminal, operated by Deutsche Energy Terminal GmbH, commenced commercial service in August 2025, with an initial capacity of 1.9 billion m³ per year ([Reuters, 2025b](#)). Simultaneously, the SALCOS project at Salzgitter AG is replacing blast furnaces with hydrogen-based direct-reduction units, a key step towards carbon-neutral steel (Salzgitter AG, 2025). These initiatives position Lower Saxony as a central node in Germany's hydrogen economy, linking North Sea wind generation with inland industrial demand.

Finally, **agriculture** remains both traditional and technologically advanced. In May 2025, the *Landesamt für Statistik Niedersachsen* (LSN) reported 6.86 million pigs on 3,700 farms,

accounting for 33% of Germany's herd (LSN, 2025e). Though herd sizes are declining, productivity and value-added per holding are rising. Crop yields in 2024 improved modestly after the 2022–2023 drought years, with cereals and maize benefiting from adequate rainfall. The agri-food sector's gross value added increased by 2.6 per cent, reinforcing its contribution to regional exports. Processing industries—meat, dairy, and feed—are concentrated in Weser-Ems and Oldenburg, linking primary production with global supply chains.

Transformation pressures in automotive and energy sectors are reshaping **labour demand**. The IHK Niedersachsen (2024) identified **acute shortages in mechatronics, electrical engineering, and digital maintenance roles**. Reskilling initiatives through dual training (*duale Ausbildung*) and technical universities have expanded accordingly. Demographic change remains a constraint: the proportion of residents over 65 exceeded 22 per cent in 2025 (LSN, 2025f). Migration partly offsets ageing, yet rural depopulation challenges labour availability in agriculture and construction. Gender and equality indicators show gradual improvement; female participation reached 75% in 2024, up two points from 2020.

The IHK Niedersachsen (2024) "Standort Niedersachsen 2024" paper described conditions as "alarmingly weak," reflecting global uncertainty and regulatory load. Nevertheless, major energy and logistics projects buoyed confidence. The state development bank NBank approved €1.68 billion in 2024 funding across 21,000 projects, its highest post-pandemic level ([NBank, 2025](#)). These investments targeted SME digitalisation, housing, and energy efficiency. Fiscal stress, however, limits municipal co-financing. The Landesrechnungshof (2024) warned that deferred maintenance in education and transport infrastructure undermines competitiveness. Coordinated state–federal initiatives are essential to unlock EU and private capital.

Medium-term prospects remain cautiously positive. Structural drivers such as electromobility, hydrogen, offshore wind, and logistics are expected to continue offsetting cyclical headwinds. Expected real growth averages 1–1.5 per cent annually through 2027 ([NORD/LB Research, 2025](#)). Risks include slower EV adoption, supply-chain fragmentation, and fiscal consolidation. Opportunities lie in the **North Sea energy hub strategy** and the **European Hydrogen Backbone network**, both anchored in Lower Saxony's ports and pipelines. In addition, the upcoming Apply AI strategy and Clean Industrial Deal at the EU level should unveil new opportunities for the transformation of Lower Saxony's most competitive industry "verticals", including in manufacturing, energy, space and agriculture.

1 Methodology

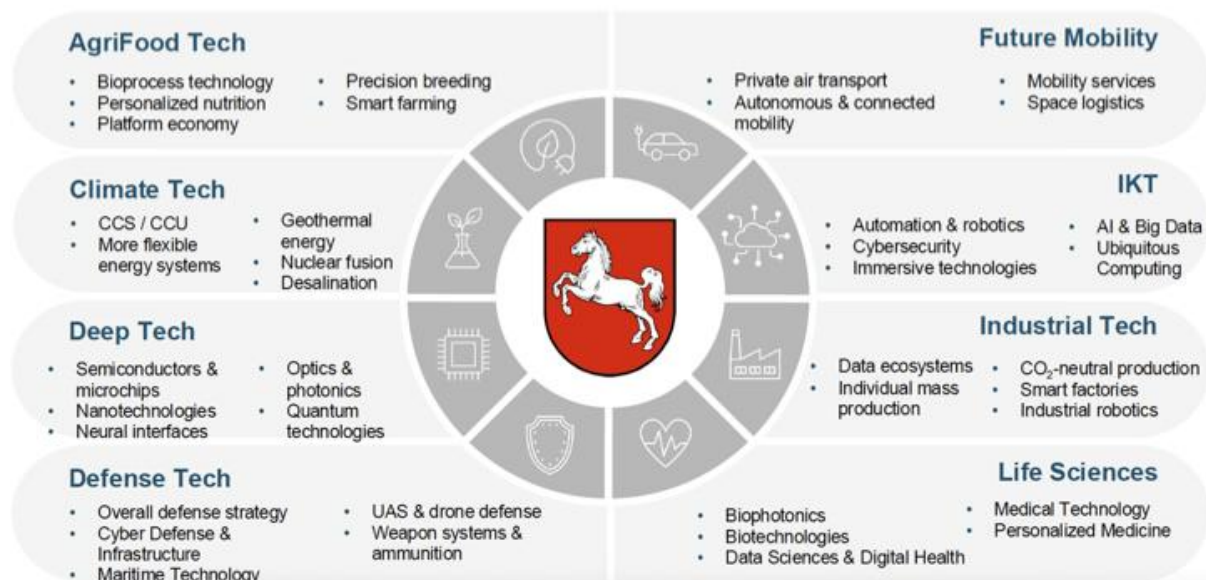
In this report, we integrate **three large-scale datasets on scientific publications (250 million records from OpenAlex, covering 2010–May 2025); patents (7 million documents from the OECD RegPat database, 2010–2024) and investment in startups (Crunchbase Pro data, 2010–May 2025)**. It is important to note that the report therefore does not include private R&D investments in large companies. Each dataset is classified into 39 KSTs (see Figure 1 below) using machine learning algorithms, existing classification systems, and expert review. More specifically:

- The analysis of patents reveals the technological relatedness between key strategic domains, and is carried out based on normalised co-occurrences on the same patent documents, which is then used to build a recommender system and evaluate untapped technological potential.
- The analysis of publications unveils the scientific relatedness between key strategic domains, and is based on normalised co-occurrences on the same scientific publication. The results are used to feed the recommender system and evaluate untapped scientific potential.
- Investment analysis measures investment relatedness between key strategic domains. Here too, we rely on normalised co-occurrences on the same funded startup. The results are used to validate our classifications.

Key indicators include **absolute and per capita counts**, **Revealed Comparative Advantage (RCA)**, and **relatedness density**. Composite indices are calculated by averaging and scaling patent, publication, and investment scores, balancing both absolute and relative strengths. This analysis allows us to identify which technologies require the largest investments to close gaps with other countries, but also to identify innovation opportunities to be leveraged at the level of Lower Saxony.

Figure 1 below shows the list of the 39 KSTs that form the scope of this report. As shown, KSTs belong to several key sectors for the economy of Lower Saxony, including Agrifood to Life Sciences, Deep Tech, Defence, Manufacturing, Mobility.

Figure 1 – Selected Key Strategic Technologies for Lower Saxony



Source: authors' elaboration

How to read this report: a guide to consulting the data

Many of the figures and graphs included in this document are static representations of richer interactive tools. To gain the full benefit of this analysis, readers are strongly encouraged to explore the hyperlinks provided in the text and figure captions. These links lead to interactive visualisations that contain a wealth of additional data. For instance, while the main report offers deep dives into selected Key Strategic Technologies (KSTs), the complete analyses for all 39 KSTs are [available online](#) in interactive format.

You will be able to consult:

- 3 domain space graphs.
- 3 treemap graphs.
- 7 smart investment graphs (including graphs for Noord-Brabant, Oberbayern and Midi-Pyrénées.
- 116 Organisational ecosystems graphs.
- 78 Maps & Networks graphs.

For a total of 205 interactive graphical visualisations.

2 Analysing Lower Saxony's Competitiveness in 39 Key Strategic Technologies

Being competitive in KSTs is particularly important in the context of a changing geopolitical landscape, increased technology insecurity, as well as rising importance of general-purpose technologies such as AI, which is expected to underpin the transformation of leading economies in the years to come. Even within the selected domains, **not all KSTs are equally foundational**; moreover, given public finance constraints and current re-prioritisation of investment at the national and EU level towards defence, it is important to note that **not all KSTs are dual use technologies**, and as such likely to cater to the region's geo-economic needs; this is also relevant as in the future EU research and innovation funding will focus particularly on technologies with both military and civilian uses ([ESIR 2025](#)).

One feature that is distinctive of each KST is its links and hierarchical relations with other technologies. Below, we present three graphs that show (statically) the interrelations between KSTs when measured in terms of co-occurrences in patent claims, scientific publications and investment. Figure 2 shows the inter-linkages in terms of patents: the interactive version shows how foundational technologies such as i.a. "AI & Big Data", "Quantum", "Data Sciences & Digital Health" and "Autonomous and Connected Mobility" are comparatively more linked to other, downstream technological domains such as Space Logistics. This, in turn, means that **even if Lower Saxony holds a leading position in automotive, lagging behind on transformational technologies such as AI may weaken its position and exacerbate its dependency on foreign technologies in the future**. This, in turn, may alert policymakers and businesses that **something has to be done to strengthen the country's competitive position in the ever-changing global geopolitical landscape**.

Figure 2 – Selected Key Strategic Technologies and their interrelations - Patents



Source: <https://www.paballand.com/ceps/lower-saxony/domain-space/regpat.html>

Likewise, Figure 3 shows the links between KSTs in scientific publications, revealing (in the [interactive graph](#)) a similar degree of centrality and “betweenness” of “AI & Big Data”, “Ubiquitous Computing” and umbrella KSTs such as “Medical Technologies”.

Figure 3 – Selected Key Strategic Technologies and their interrelations – scientific publications



Source: <https://www.paballand.com/ceps/lower-saxony/domain-space/openalex.html>

The investment landscape appears even more integrated, with “AI & Big Data” and “Automation and Robotics” standing out in terms of their foundational nature with respect to other KSTs (see, for the static version, Figure 4 below). The complete files are available on separate, [interactive websites](#).

Figure 4 – Selected Key Strategic Technologies and their interrelations – investment



Source: <https://www.paballand.com/ceps/lower-saxony/domain-space/crunchbase.html>

3 Strategic Investment Opportunities in Lower Saxony

3.1 Competitiveness Diagnostics: Patents, Publications and Startup Investment

This section takes a bottom-up approach, following smart specialisation principles, to identify the **most promising technologies (among the selected KSTs) for strategic investment in Lower Saxony**. This is obtained by analysing regional strengths using indicators like relatedness density and RCA, which allow us to evaluate matching between technologies and regions. The results, also presented as interactive visualisations, directly suggest where targeted investments should be made for maximum impact.

Figure 5 below shows the main findings of our technological competitiveness diagnostic. Based on patent data, Lower Saxony demonstrates the characteristics of an **industrial powerhouse**, displaying **strong specialisation in KSTs such as mobility services** (amounting for over 19% of the total, plus another 8% represented by autonomous and connected mobility) and **green manufacturing** (CO₂-neutral production). The region's economic base integrates vehicle production, mobility services, autonomous systems, and the pursuit of CO₂-neutral industrial processes. This combination allows the state to maintain Germany's leading position in sustainable transport and advanced engineering while continuing to export high-value manufactured goods.

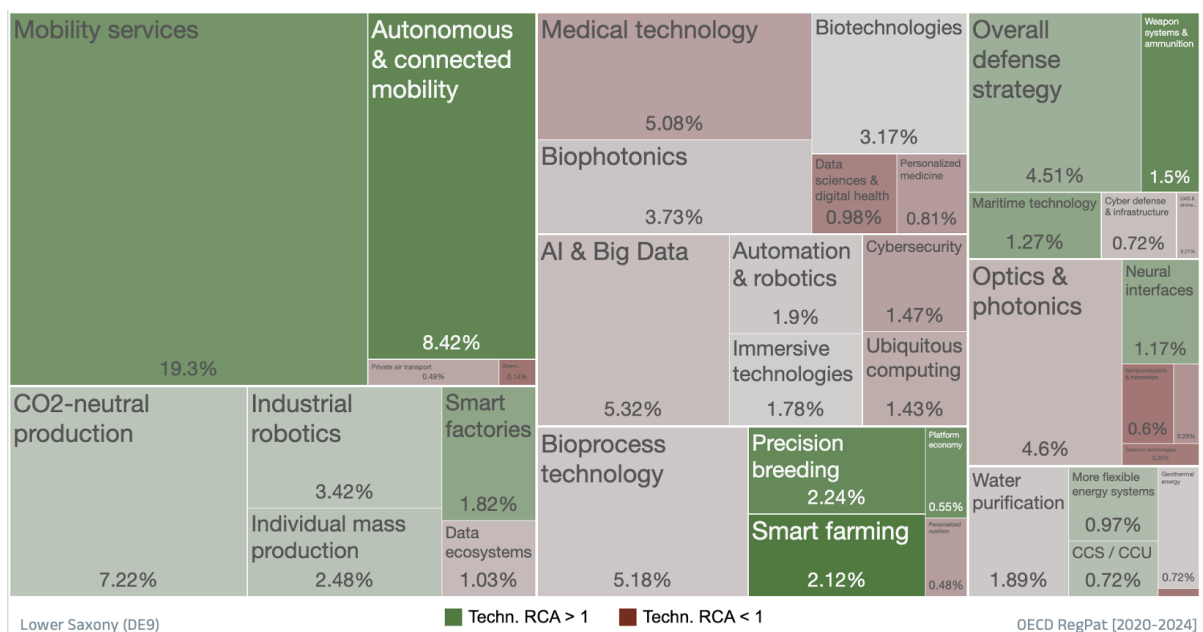
At the same time, **Lower Saxony is evolving into a twin transition leader**, coupling its deep industrial capabilities with expanding green and agri-technology sectors. Innovation in smart farming systems, precision breeding, and bio-based production illustrates how traditional agricultural strengths are being reoriented towards climate-friendly innovation.

The state's strategic assets extend beyond industry to include an **active role in defence, energy, and sustainability technologies**, all of which contribute to regional resilience and European industrial sovereignty. These assets provide a platform for cross-sectoral synergies between manufacturing, logistics, and the green-tech ecosystem.

Nonetheless, **a digital gap persists**. While artificial intelligence, robotics, and cybersecurity capacities are emerging, they remain under-developed relative to the state's industrial potential. Addressing this imbalance offers significant scope for productivity and competitiveness gains, in particular given the foundational nature of these technologies, which are poised to permeate the next evolution of those sectors in which Lower Saxony enjoys current leadership.

The next developmental step for Lower Saxony therefore lies in **shifting from industrial excellence to digital leadership, embedding data analytics, automation, and AI applications across its established strengths in mobility, energy, and agri-food production**. Achieving this transformation represents the state's largest strategic challenge for the remainder of the decade.

Figure 5 – Technological competitiveness diagnostic



Source: <https://www.paballand.com/ceps/lower-saxony/treemaps/regpat.html>

A different picture emerges when it comes to scientific specialisations, as shown in our Figure 6. Based on publications data, **Lower Saxony possesses a strong scientific foundation in health and photonics, anchored by its expertise in medical technology, optical systems, and biophotonics**. Universities and research institutes in Hannover, Göttingen, and Braunschweig have cultivated internationally recognised competencies in these fields, fostering innovation that bridges engineering and life sciences. This scientific edge contributes significantly to the state's research intensity and paves the way for translating fundamental science into applied

industrial outcomes. As we shall see below, such translation is not always happening to its full potential.

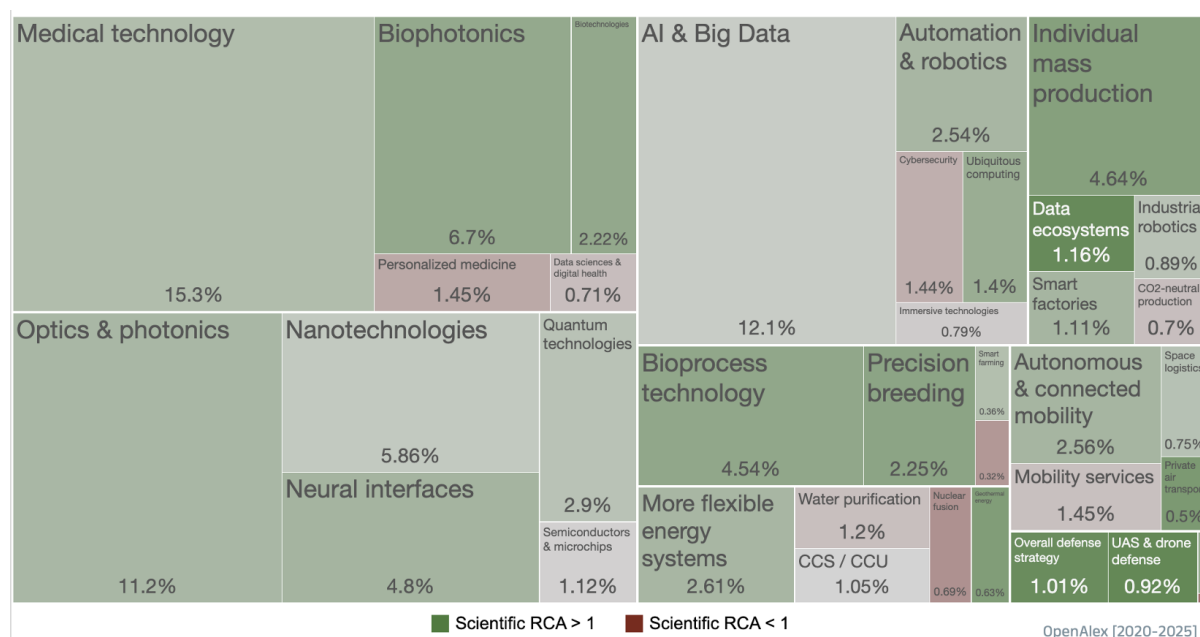
Alongside this scientific base, the region is developing **emerging digital strengths in AI, big data analytics, and robotics, particularly where these technologies intersect with established industrial domains**. Collaborative initiatives between academic laboratories, manufacturing firms, and healthcare providers are beginning to yield practical applications—ranging from AI-assisted diagnostics and predictive maintenance systems to data-driven production optimisation.

However, **Lower Saxony's degree of specialisation remains limited in several frontier domains, including cybersecurity, clean energy digitalisation, and immersive technologies such as virtual and augmented reality**. These areas currently exhibit lower institutional density and fewer corporate champions than the state's more traditional industrial and research fields.

A notable development is the **growing convergence between data ecosystems, smart factories, and digital health**. This integration is producing new business models and research synergies, illustrating the state's capacity to operate across disciplinary and sectoral boundaries. It also reflects a wider European trend towards hybridised innovation systems where manufacturing and healthcare intersect through digital platforms.

Consequently, there exists **a strategic opportunity for Lower Saxony to leverage its health-technology leadership as a catalyst for next-generation AI and industrial innovation**. By aligning its photonics and medical-engineering capabilities with emerging digital technologies, the state can position itself at the forefront of Europe's evolving digital-industrial ecosystem, consolidating both competitiveness and societal value creation.

Figure 6 – Scientific Competitiveness Diagnostic



Source: <https://www.paballand.com/ceps/lower-saxony/treemaps/openalex.html>

When it comes to investment in startups, Lower Saxony's profile appears highly concentrated, with **biotechnology and personalised medicine** attracting approximately 74 per cent of total

private investment in startups during 2020–2025. This extreme specialisation underscores investor confidence in the region's life-science capabilities and its established research infrastructure in biomedical engineering, diagnostics, and pharmaceutical development. However, such concentration also signals an imbalance in the regional innovation portfolio, as **financial capital flows (insufficiently and) disproportionately towards health-related ventures while other technological domains remain under-capitalised.**

In comparative terms, **AI and big data** occupy a visible share of investment activity (around **8.6%**) yet the region's **revealed comparative advantage (RCA) remains below one**, suggesting that global investors display greater confidence in competing ecosystems located elsewhere. This underperformance contrasts with Lower Saxony's strong academic output in AI research, revealing **a structural gap between scientific excellence and commercial scaling.**

A series of emerging niches demonstrate nascent competitiveness. **Bioprocess technology** accounts for roughly 5% of recent investment and exhibits an RCA above one, reflecting technological know-how in industrial biotechnology and fermentation processes. Similarly, **space logistics**, although still small at about 2.5% of total investment, has begun to develop a clear specialisation trajectory, drawing on the state's aerospace engineering heritage in Hannover and Stade.

Persistent **weaknesses in digital security, automation, and robotics limit cross-sectoral diffusion of advanced digital technologies.** Despite national emphasis on Industrie 4.0, the regional presence of cybersecurity firms and robotics startups remains thin, resulting in a systemic vulnerability across both manufacturing and public-sector applications. Investment patterns therefore display a duality: robust capitalisation in life sciences but under-investment in frontier digital domains, such as secure data infrastructure, advanced robotics, and immersive technologies.

The state's innovation landscape consequently reveals, at least when looking at investment data, a **deep life-science bias.** While financial investment is overwhelmingly concentrated in biotechnology and medicine, the underlying scientific and patent activity presents a broader distribution across disciplines. This divergence implies that financial capital is overspecialised relative to the knowledge base, potentially constraining the translation of academic advances in non-biomedical fields into commercial ventures.

Conversely, Lower Saxony exhibits strong research performance but weak scaling capacity in AI and big data. The region's universities record high scientific RCA in these domains, yet corresponding patent and investment indicators remain subdued. This mismatch, as already highlighted, highlights a **translation bottleneck from laboratory discovery to startup formation and market uptake.** Addressing this gap will be critical for enhancing digital competitiveness.

A **notable area of strength for Lower Saxony lies in industrial technology conversion** in specific areas, **particularly in manufacturing, mobility, and energy.** Here, Lower Saxony demonstrates clear continuity from scientific research through patenting to market deployment. Such coherence signifies the presence of mature industrial ecosystems capable of absorbing innovation and transforming it into economic value. **Defence and space industries have emerged as promising, though still small, industrial niches.** Despite limited research intensity,

these sectors display high technological RCA, indicating applied specialisation built upon pre-existing industrial capabilities in materials engineering, propulsion, and complex systems integration.

Overall investment behaviour suggests that **financial markets continue to chase biotechnology, yet the region's comparative industrial edge resides in mobility and green manufacturing**. Leveraging synergies between scientific excellence in AI and the state's manufacturing base could reposition Lower Saxony as a European leader in AI-enabled industrial production, ready to benefit from the actions foreseen i.a. under the Apply AI strategy. The coordination potential between data science, energy systems, and smart mobility represents one of the region's most significant strategic assets for the latter half of the decade.

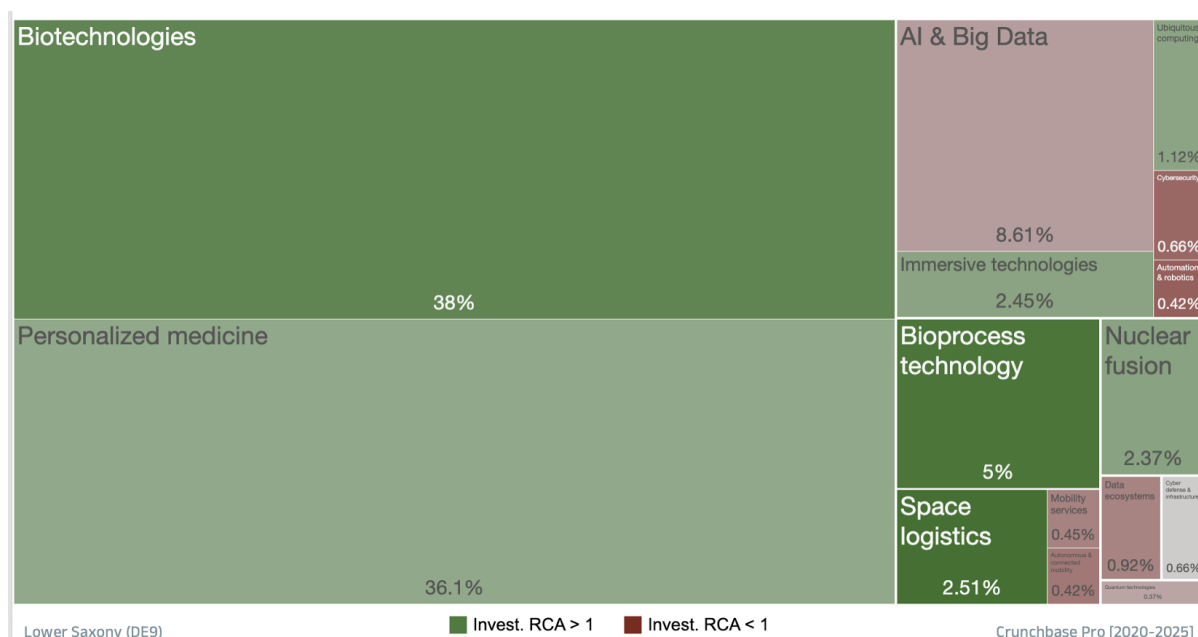
Nevertheless, **cybersecurity and robotics deficiencies** persist across all layers—research, patents, and investment—constituting a systemic gap in the enabling technologies required for secure digital transformation. Parallel to this weakness, green technologies, particularly CO₂-neutral production methods and flexible-energy solutions, consistently register RCA values above one in both scientific publications and patent output. These indicators confirm an emerging sustainability advantage, aligning regional industrial strategy with European Green Deal objectives.

An intriguing feature of this landscape is the **“biotech ecosystem maturity paradox.”** Despite commanding the vast majority of investment, biotechnology does not yet produce a proportionate volume of patent filings or new-product launches. This imbalance implies that the ecosystem's financial maturity has outpaced its innovative yield, possibly due to long development cycles and regulatory complexity.

Taken together, the overall pattern indicates that Lower Saxony's innovation system is **scientifically broad but financially narrow**. It possesses a diverse and sophisticated research foundation across multiple domains, yet investment remains channelled into a limited subset of life-science fields. To achieve balanced, sustainable growth, the state will need to diversify its financial ecosystem, strengthen translational mechanisms in AI and digital manufacturing, and integrate cybersecurity and robotics as foundational enablers of its next development stage.

All in all, venture capital in Lower Saxony appears to be **under-developed compared to other German states**, particularly when judged by startup financing metrics and deal flow. According to the latest national data, Lower Saxony startups received just **25 financing rounds** in 2024, a very low figure compared with the top-state counts (e.g., Berlin with 256 rounds) ([Ernst & Young, 2025](#)). In terms of financing volume, Lower Saxony also lags behind, with markedly fewer large-ticket deals and less visibility in high-growth segments such as artificial intelligence, mobility or climate tech. The national landscape further reinforces this gap: Germany's total VC investment remains below 0.2 % of GDP, well behind peer countries such as the UK (≈0.5%) and the United States, indicating a broader national constraint on venture-capital depth ([OECD, 2025](#)). Although the region has recently stepped up support through state-backed startup centres and ecosystem funding, such as the €2.31 million funding for ten startup centres across Lower Saxony to 2025, the scale and maturity of private VC activity are still significantly weaker than in more established ecosystems.

Figure 7 – Investment Competitiveness Diagnostic



Source: <https://www.paballand.com/ceps/lower-saxony/treemaps/crunchbase.html>

3.2 Smart Investment Opportunities in Lower Saxony

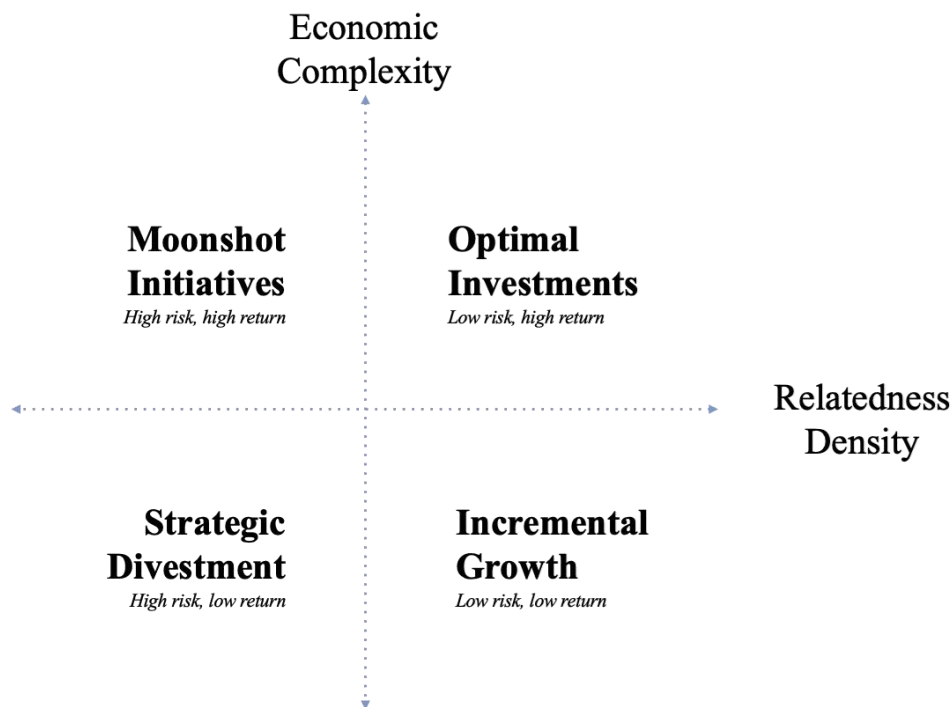
Below, we present a graph with four quadrants, in which the **horizontal axis measures the feasibility for Lower Saxony to invest in a specific KSTs in the future**, based on current capabilities. Feasibility is measured by relatedness density, quantifying how closely related a region's existing domains are to a potential new domain. It is calculated as the share of related domains (already present in the region) out of all possible related domains for that target. A higher relatedness density means the region has a stronger foundation to lead (now and in the future) in that new domain.

On the vertical axis is the technology's complexity. Importantly, we take complexity as a proxy for the prospective economic impact of a given technological domain. This is due to the original method of "reflections" (and its eigenvector reformulation), which measures complexity by capturing how diverse locations are and how exclusive the activities or technologies they host are, using iterative network metrics. Here we use a variation that is more robust to smaller techs: instead of using RCA or eigenvector centrality, we use a drop-shares scaling coefficient based on how quickly a technology's presence drops across top locations.

Figure 8 shows the legend for our resulting four-quadrant graph. The North-West quadrant includes domains for which investment, based on patent data, would be rather risky given that Lower Saxony does not seem to possess a comparative advantage at the moment, but the potential added value of an investment would be significant (so-called "moonshots", i.e. high-risk, high-return initiatives). The North-East quadrant, to the contrary, shows areas where Lower Saxony is well-equipped to invest, given its current capabilities, and where technologies

are complex and difficult to replicate, leading to a significant economic impact ("Optimal investments", i.e. low-risk, high-return areas). In the bottom part of the graph, the South-East graph showcases domains in which Lower Saxony has important capabilities, but where technologies are less complex and more replicable, and as such the prospective impact would be comparatively lower ("incremental investment", i.e. low-risk, low-return investment). Finally, the South-West quadrant shows areas in which complexity and economic value are low, and Lower Saxony has no comparative advantage, so absent a major strategic effort, the recommendation would be to divest ("Strategic divestment", i.e. high-risk, low-return areas).

Figure 8 – How to read our four-quadrant investment opportunity graph

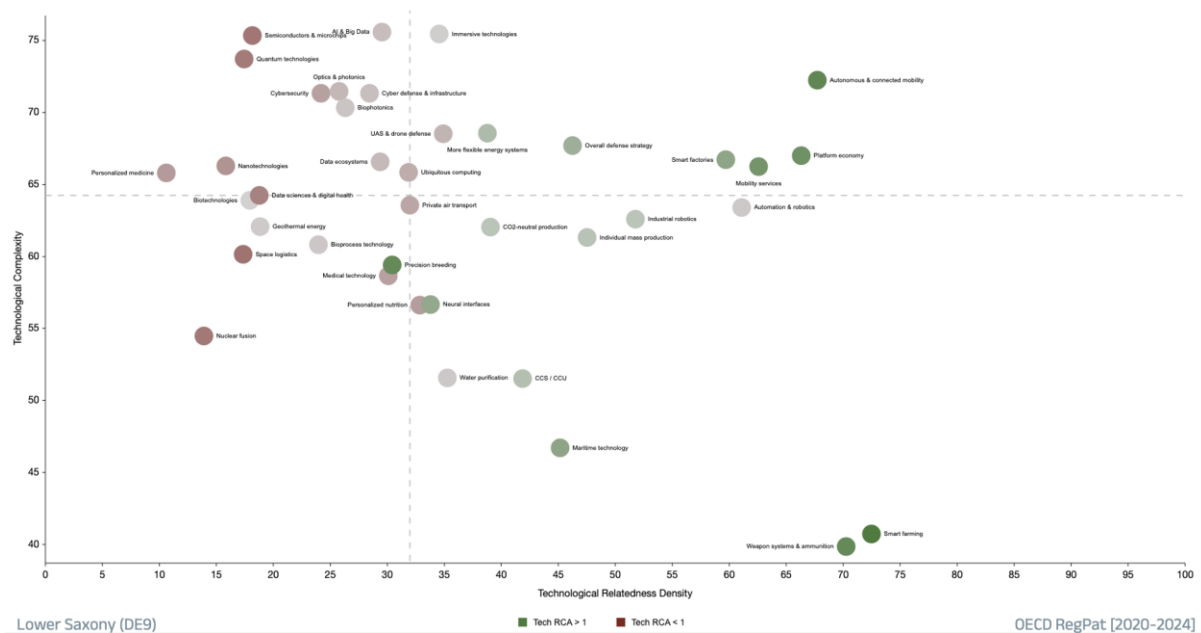


Source: Authors

Figure 9 analyses the Lower Saxony region from a **technological perspective**, highlighting areas in which complexity and relatedness density are both high, and as such would deserve to be prioritised as investments with relatively low risk and high return. The colour scheme here reveals KSTs for which the relatedness competitive advantage (RCA) index is above 1. Here, **optimal investment areas include mobility, including most notably autonomous and connected mobility, plus smart factories, defence and flexible energy systems**. Foundational domains such as AI & big data and semiconductors and chips emerge as potential areas for moonshots, alongside other areas such as biotech, quantum, cybersecurity and photonics. In all these areas, the red colour signals a relative competitive advantage below one. In the graph, promising areas with lower levels of complexity but positive RCA include also industrial robotics and individual mass production. Areas of lower complexity on average, which may include also

some advanced applications, include weapon systems and ammunitions, smart farming and maritime technologies.

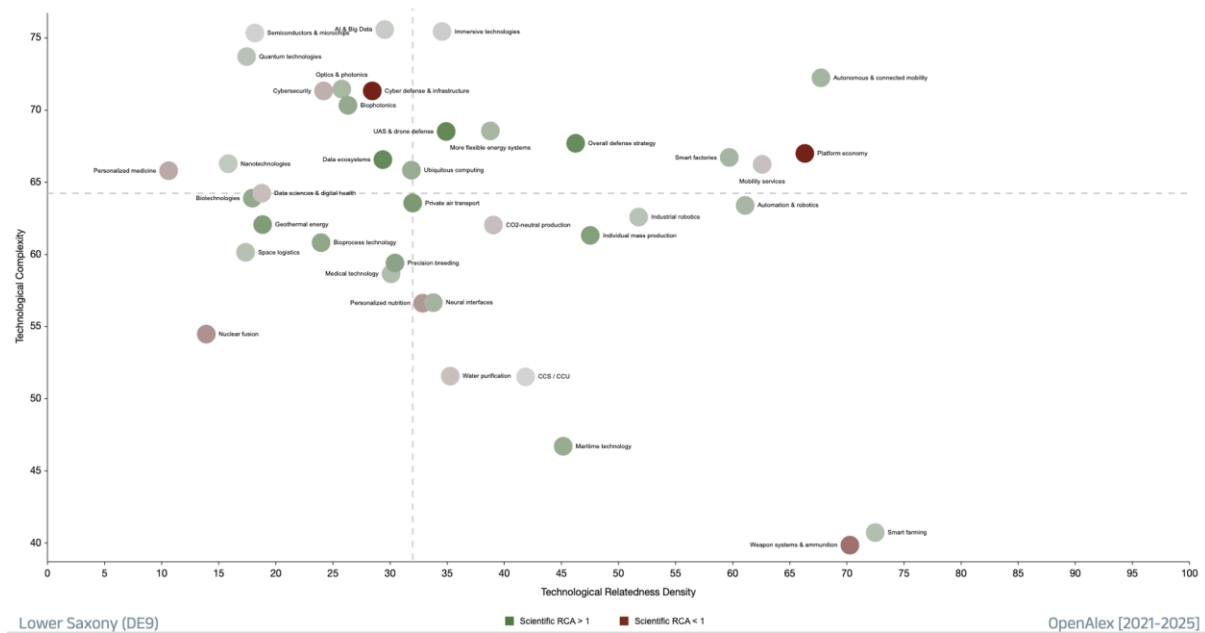
Figure 9 – Technological opportunities in the Lower Saxony region (2020–2024)



Source: <https://www.paballand.com/ceps/lower-saxony/smart/regpat.html>

Figure 10 below repeats the exercise by looking at the **Scientific Competitive Advantage index**. Seen from the lens of scientific publications, Lower Saxony appears as a leading performer in autonomous and connected mobility, smart factories and defence tech (including drones), whereas its position in the platform economy is advanced, but its relative competitive advantage vis à vis global competitors is relatively low. Promising areas that can add a lot to the economy, but where the region does not yet have all the needed capabilities to lead, include quantum computing, nanotechnologies, AI and big data, semiconductors, cybersecurity and biophotonics. Areas of relatively lower complexity, where the scientific specialisation of Lower Saxony puts it at a comparative advantage, include smart farming and maritime technologies.

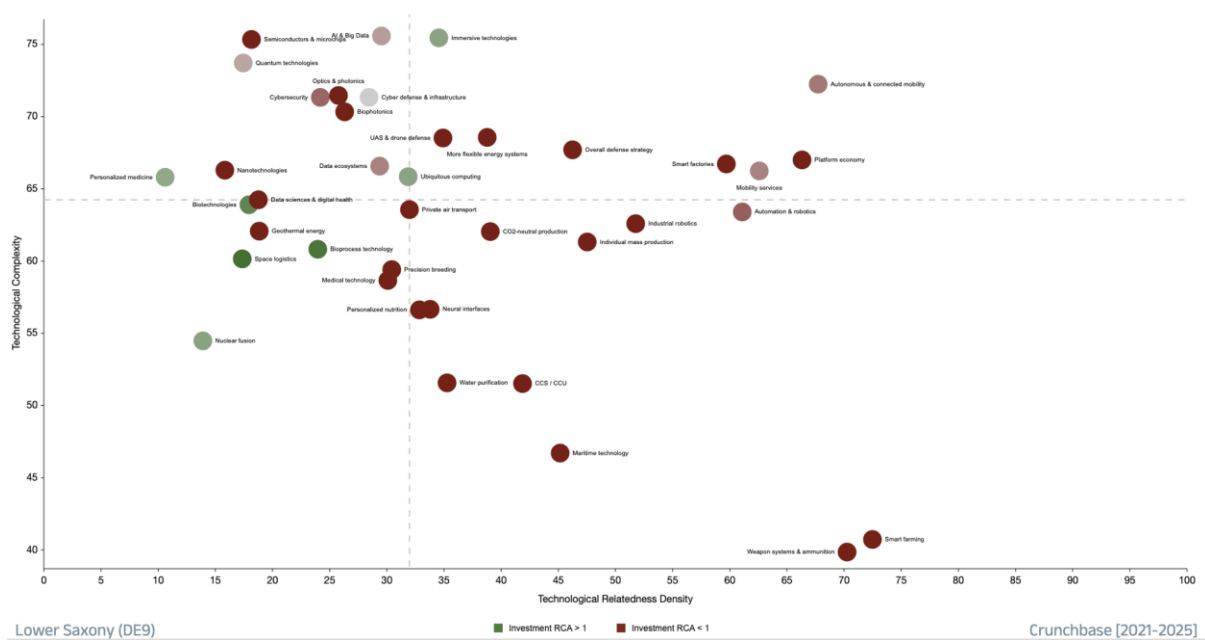
Figure 10 – Scientific opportunities in the Lower Saxony region (2021–present)



Source: <https://www.paballand.com/ceps/lower-saxony/smart/openalex.html>

Finally, Figure 11 shows the results with a colour scheme that refers to the investment RCA. Here, the dominance of the U.S. in terms of venture capital investment in startups makes almost all areas perform lower in terms of relative competitive advantage. Yet the figure shows that the region can invest in complex, high value areas such as immersive technologies, autonomous and connected mobility, smart factories, the platform economy, defence, UAS and drones and ubiquitous computing. Areas that can add a lot to the economy, but where the region is not yet possessing the needed comparative advantage, include quantum, nanotechnologies, AI & big data and personalised medicine.

Figure 11 – Funding opportunities in the region of Lower Saxony (2021–present)



Source: <https://www.paballand.com/ceps/lower-saxony/smart/crunchbase.html>

Finally, it is possible to show a summary graph (Figure 12), which illustrates the combined results obtained for patents, publications and investment for each region and each of the 39 KST. These graphs provide a bird's eye view of optimal investments, potential moonshots, areas for consolidation and incremental growth and areas that may need divestment in Lower Saxony. At the technological frontier, **the state exhibits notable potential for investment in AI, immersive technologies, and autonomous mobility**. These areas combine high complexity—reflecting advanced knowledge requirements and substantial R&D intensity—with extensive interconnections to other technological fields. They therefore serve as strategic anchors for next-generation competitiveness, underpinning new value chains in digital manufacturing, transport, and intelligent systems.

Biotechnology and data ecosystems occupy a central hub position within this network. They function as bridging domains between the high-complexity frontiers of digital innovation and the applied life-science and health-technology sectors. The co-location of bioinformatics expertise, health-data infrastructures, and digital-platform development fosters dense knowledge flows and supports translational research. These linkages position Lower Saxony to capitalise on converging trends in computational biology, digital therapeutics, and personalised medicine.

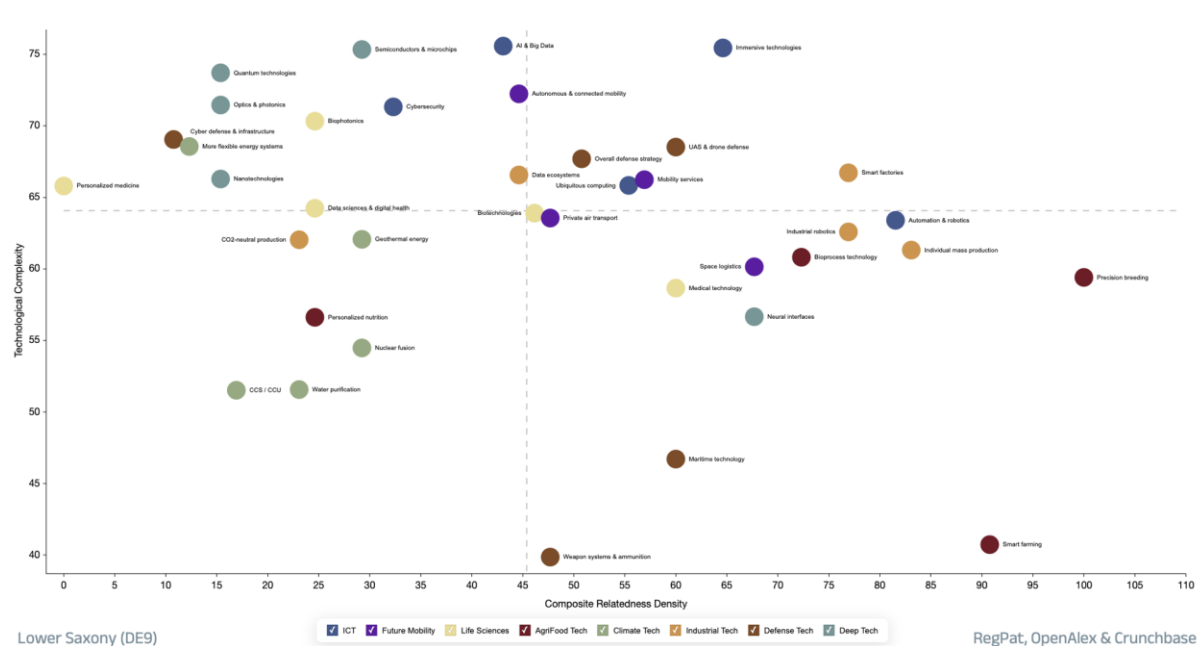
In contrast, **industrial and manufacturing technologies** (e.g., automation, robotics, and smart-factory systems) **are characterised by moderate technological complexity but strong embeddedness within the regional economy.** Their close integration with existing production networks makes them well suited to scaling applied innovation, allowing the state's small and medium-sized enterprises (SMEs) to adopt incremental technological upgrades. This mid-complexity tier constitutes the backbone of Lower Saxony's innovation diffusion capacity, translating high-end research into tangible industrial productivity gains.

The agrifood and climate-technology sectors, encompassing precision breeding, smart farming, and carbon-capture solutions, exhibit lower intrinsic complexity but a high degree of relatedness to other domains. Their knowledge and supply-chain overlap with machinery, data analytics, and environmental engineering create fertile ground for easy diversification. This suggests that incremental innovation in agriculture and climate adaptation can be achieved through modest technological extension from existing industrial capabilities, providing inclusive pathways into the green transition.

At the periphery of the system, defence, maritime, and weapon technologies persist as isolated, low-complexity niches. They remain strong within local industrial clusters, benefiting from regional manufacturing know-how and established procurement networks, yet are weakly connected to broader innovation ecosystems. The limited cross-sectoral exchange in these fields constrains spill-over effects and restricts their contribution to the state's overall technological dynamism.

Taken together, this configuration portrays Lower Saxony as **an economy whose innovation frontier is anchored by AI and mobility systems, supported by a biotechnological and data-driven hub, and underpinned by robust but mid-complexity industrial technologies**. Peripheral yet strategically relevant sectors such as agrifood, climate tech, and defence provide diversification potential but require stronger linkages to the central innovation network. Policy interventions that enhance these connections—particularly between digital frontiers and traditional manufacturing—would accelerate knowledge diffusion and reinforce the state's position within Europe's advanced-technology landscape.

Figure 12 – Summary graph – opportunities in the Lower Saxony region (data since 2020)



4 Key Players in the Lower Saxony R&I Ecosystem

Our analysis of data on patents, scientific publications and investment in new startups allows us also to study the patent landscape, key players in the scientific ecosystem, and inter-regional cooperations of actors over the past years in Lower Saxony.

4.1 Patent Landscape in the Innovation Ecosystem

The patent landscape shows Lower Saxony's **remarkable specialisation in a number of key areas of innovation**, with strong potential to address future developments in clean tech, smart mobility and industrial solutions. It also features the region's **reliance on a few established players**, often with very high market share in their specific market segment. Lower Saxony's economy is **strengthened by the presence of several "hidden champions,"** as defined by Hermann Simon, which underpin its resilience and global competitiveness in niche industrial and technological sectors. Their modest public visibility belies their strategic significance to both regional economic development and Germany's broader innovation landscape. Collectively, these firms contribute to a diversified industrial structure in Lower Saxony that balances the prominence of major corporations, reinforcing the region's capacity for high-value production and applied scientific excellence.

The landscape of **venture capital investment in startups is not very well developed** in Lower Saxony, and as a result a few significant investments take the lion's share.

4.2 Key Players in the Scientific Ecosystem

Looking at the academic ecosystem, **Leibniz University Hannover** dominates the scene with almost 26% of peer-reviewed publications in the past five years. It is notable for its engineering, science and data-oriented profile, and has a strong focus on disciplines such as electrical engineering, computer science, natural sciences and mechanical engineering. The university is home to the Laboratory of Nano and Quantum Engineering (LNQE), an interdisciplinary centre for nanotechnology combining physics, chemistry and engineering. Its faculty publishes across a broad range of STEM fields, including computer science / data science, materials / nanotechnology engineering, and applied physics / engineering domains.

Next is the **University of Göttingen**, a major research university with broad disciplinary coverage and a strong reputation in the humanities, natural sciences and life sciences. Areas such as biology, chemistry, material science, physics and data-driven research appear particularly strong.

A strong patent portfolio is held also by the Technische Universität Braunschweig (**TU Braunschweig**), a major technical university founded originally in 1745 and now a member of the TU9 network of leading German institutes of technology. Key research clusters include mobility and vehicle systems (automotive engineering, aerospace, inter-modal transport), metrology and measurement science (in cooperation with the Physikalisch-Technische

Bundesanstalt, PTB), smart city / urban systems, life sciences / biotechnology, and digital / engineering sciences. While the university publishes across STEM disciplines, its relative concentration leans toward chemistry / materials, physical sciences / engineering, and mobility / vehicle systems rather than purely life-science or health fields.

4.3 Inter-Regional Cooperations

Lower Saxony's research and innovation (R&I) collaboration patterns show a strong regional character, with the state engaging primarily in partnerships with other German Länder rather than with wider European or global innovation ecosystems. Analysis of co-publication and patent co-application data indicates that **over 70% of Lower Saxony's formal R&I linkages are still intra-national, with less than 15% involving cross-border European partners, and even fewer extending globally** (Federal Ministry of Education and Research [BMBF], 2024).

In the future mobility sector, **Berlin** emerges as the most significant partner, driven by shared interests in autonomous systems, digital vehicle platforms, and mobility-as-a-service models (ESPON, 2021).

Meanwhile, in the agrifood technology domain, Lower Saxony maintains strong ties with regions such as **Münster**, particularly around precision breeding and smart farming solutions, and with **Detmold** for innovations in personalised nutrition and bioprocessing (BMBF, 2024).

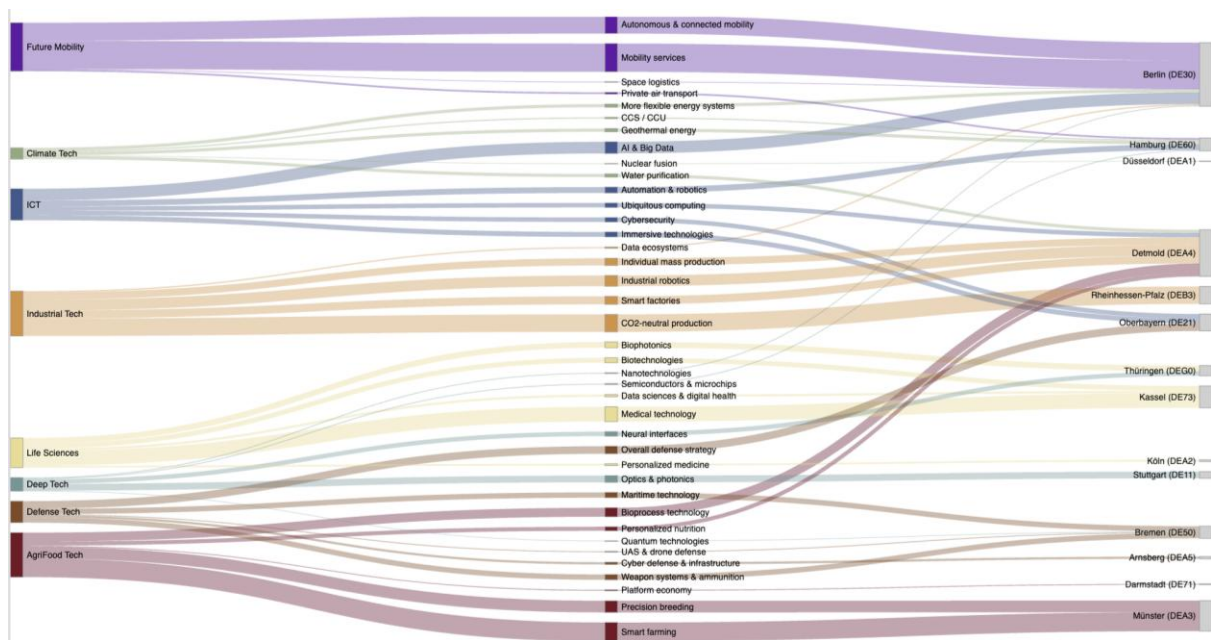
Detmold and **Rheinhessen-Pfalz** are also key collaborators in industrial technologies, including robotics, mechatronics, and advanced materials—reflecting shared specialisations in mechanical engineering and green manufacturing (State of Lower Saxony, 2025).

In the life sciences, the network becomes even more dispersed, with emerging partnerships involving **Thüringen** (notably Jena's optics and biotech cluster) and **Kassel** (for medical engineering and translational research) (ESPON, 2021).

Additionally, historical proximity and shared industrial legacies underpin collaboration with **Bremen** in defence and aerospace innovation, particularly around naval systems, maritime security, and dual-use technologies (State of Lower Saxony, 2025).

While this regionalised cooperation strengthens local integration and deepens national value chains, it also highlights a missed opportunity: **Lower Saxony's limited international linkage leaves its innovation system potentially vulnerable to insularity, limiting access to foreign technologies, investment, and regulatory learning.**

Figure 13 – Existing linkages (technologies) and top partners



Source: <https://www.paballand.com/ceps/lower-saxony/maps/regpat.html>

When it comes to scientific collaborations, as illustrated in Figure 14, Lower Saxony's R&I network is more internationalised, with links extending beyond Germany.

In the life sciences, the region maintains strong connections with **Berlin**, particularly in biophotonics, MedTech, and digital health, while personalised medicine research aligns more closely with partners in Köln and biotech-oriented collaboration with Saarland (Federal Ministry of Education and Research [BMBF], 2024).

In the ICT domain, **Berlin** remains the primary scientific partner, especially in artificial intelligence and big data. However, in automation and robotics, cooperation increasingly involves the **UK's Oxford region**, suggesting a cross-channel research bridge, complemented by collaborations with Bremen in immersive technologies and Arnsberg in cybersecurity initiatives (ESPON, 2021). In industrial technologies, the partnership pattern remains mainly domestic, with Berlin still acting as a dominant co-publishing region.

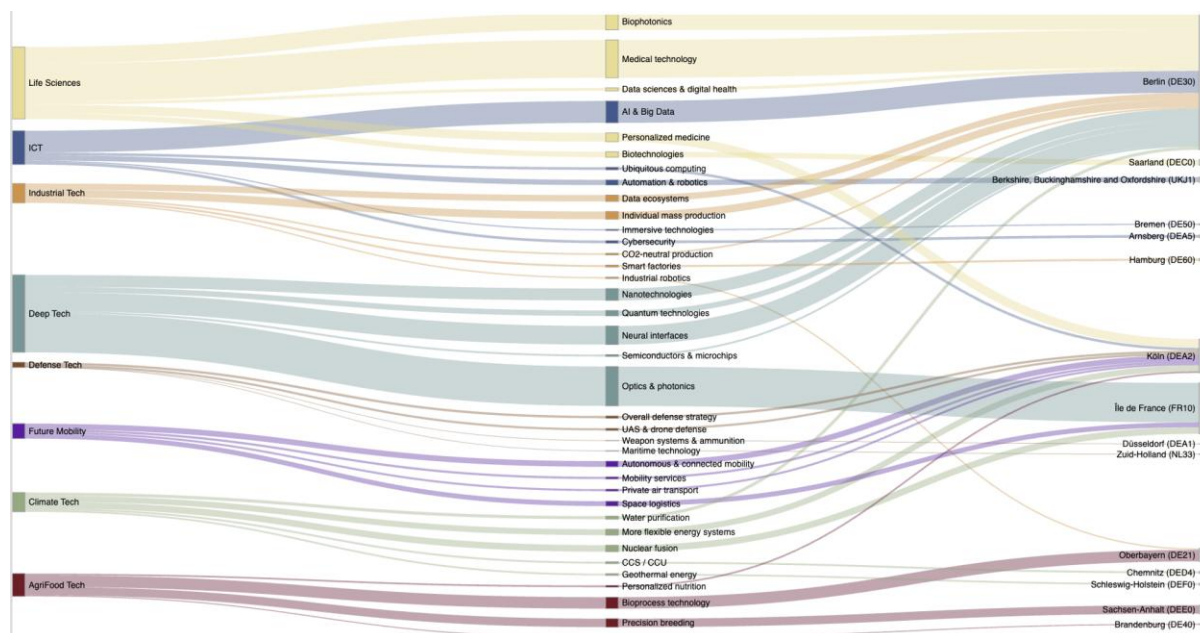
In the emerging field of deep tech, **collaborations on quantum computing, neural systems, semiconductors, and nanotechnology** also pivot around Berlin, but Lower Saxony researchers hold meaningful co-publication ties with **Île-de-France**, especially in optics and photonics (State of Lower Saxony, 2025). The defence technologies domain exhibits cooperation primarily with **Köln**, but significant linkages also exist with **South Holland (Netherlands)**, notably in maritime systems.

In the area of future mobility, **Köln** leads joint scientific production in autonomous and connected vehicles, air mobility, and transport services, while space mobility linkages are strongest with **Île-de-France**.

A similar pattern holds in climate technology, particularly on nuclear fusion research, where Paris is a major partner, alongside Berlin (notably in water purification) and **Köln** (for flexible energy systems).

Finally, in agrifood sciences, the most prominent collaborations occur with **Oberbayern** and **Sachsen-Anhalt**, focusing on bioprocessing technologies and precision breeding, respectively (BMBF, 2024).

Figure 14 – Existing linkages (science) and top partners



Source: <https://www.paballand.com/ceps/lower-saxony/maps/openalex.html>

In Section 5 below, we illustrate the network of technological and scientific linkages for select KSTs, including AI & big data, autonomous and connected mobility, and space. Interactive graphs for all KSTs are available at this [link](#).

5 Select Domains: a Deep Dive

Our analysis, based on economic complexity, allows us to further deep dive into each of the 39 KSTs, to offer a more granular view of the patterns of innovation, scientific collaboration, as well as leading players in the ecosystem. Below we do this for three selected areas.

5.1 AI & Big Data

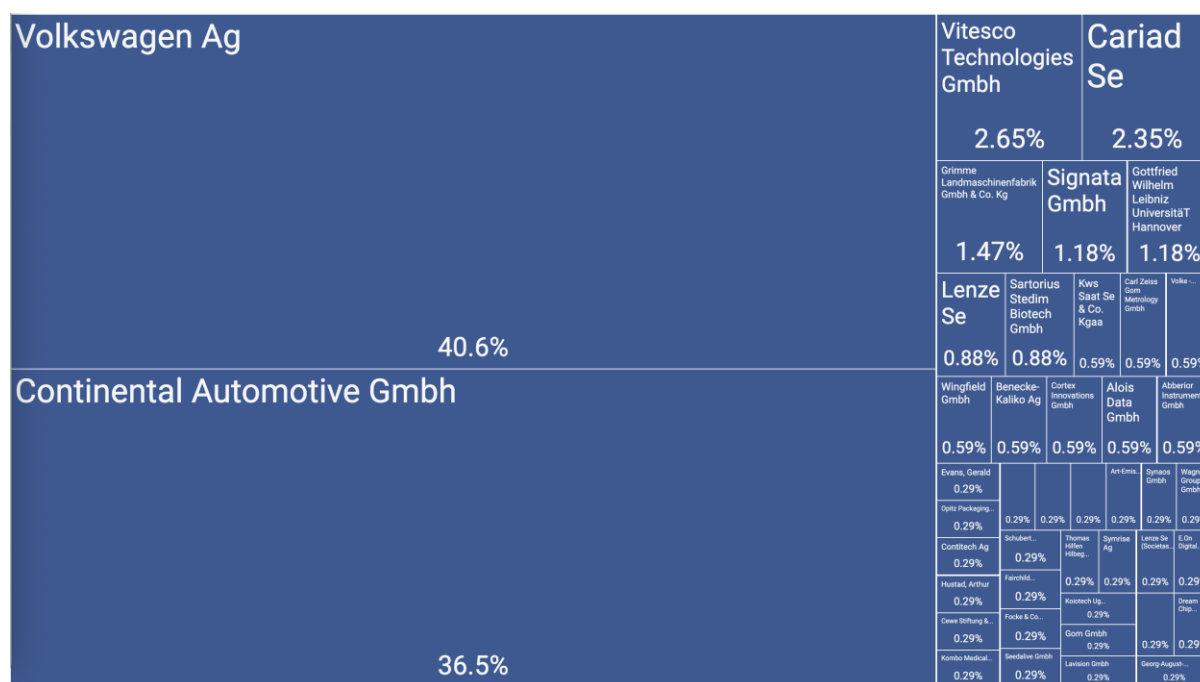
A proto-typical general-purpose technological domain, AI and big data will fuel industrial transformation in the coming years, and are poised to become essential when combined with domain specialisation in many sectors of the economy. In view of the ambitious plan laid down by the European Commission with the AI Continent and the more recent Apply AI Strategy, looking into the specialisation of Lower Saxony is essential, also to understand whether the deepening of AI uptake in industrial verticals will meet fertile ground in the region.

Figure 15 below looks at the main players in the AI ecosystem of Lower Saxony in terms of patent portfolios, showing the “applied” nature of solutions available in the region. **Volkswagen AG** holds a growing portfolio of AI-related patents, which counts for more than 40% of the total in the region. These patents cover domains such as driver-state monitoring, where eye-tracking and sensor-fusion systems use machine-learning algorithms to detect gaze direction, fatigue, or critical health events. Overall, Volkswagen’s AI patent landscape spans vehicle intelligence, production automation, digital platforms, and connected-mobility ecosystems, reflecting its shift toward software-defined mobility.

Next, with over 36% of the total patent share, is **Continental Automotive GmbH**, which holds an extensive and sophisticated portfolio of AI-related patents that reflects its position as one of Europe’s most advanced suppliers of intelligent vehicle systems. A significant share of its patents concern autonomous-driving perception, where neural networks fuse data from radar, lidar, ultrasonic sensors, and high-resolution cameras to classify objects, detect pedestrians, and interpret complex traffic scenarios. Continental Automotive’s strategic focus is on embedding AI across the entire mobility value chain—from embedded systems to automated driving, digital cockpits, cybersecurity, and intelligent components—reinforcing Lower Saxony’s and Germany’s role in next-generation automotive innovation.

The rest of the ecosystem is much more scattered, with some of the larger players (e.g. **Cariad**) belonging anyway to Volkswagen AG; or being formerly owned by Continental (**Vitesco**, originally the Powertrain division of Continental, now an independent company specialising in electrification components such as inverters, e-axles and power electronics). In addition, significant players include **Signata GmbH**, active in mechatronic systems, including actuators, gear-shift systems, haptic operating systems and full life-cycle development of systems; **Grimme Landmaschinenfabrik**, which focuses its innovation strategy on embedded sensing, real-time machine adjustment and intelligent control of agricultural systems, seeking a shift from purely mechanical inventions to mechatronic systems with data-driven action.

Figure 15 – Key players in the AI and big data ecosystem in Lower Saxony (patents)



Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/regpat/ai-&-big-data.html>

On the scientific publications front, the situation appears less concentrated and more evenly distributed. The leading player is **Leibniz University Hannover**, which focuses on two core areas, Automated Machine Learning (AutoML) and Natural Language Processing (NLP). It produces steady publications on hyperparameter optimisation, reinforcement learning, sustainable deep learning and discourse-oriented NLP, often appearing in AutoML, GECCO, and machine-learning venues. One of its advanced research centres (joint with TU Braunschweig), **L3S**—which accounts by itself for 6% of all AI-related publications in the past five years—extends this into web-scale and trustworthy AI, publishing on text mining, knowledge graphs, semantic search, multimodal scene analysis and fairness in computer vision. Overall, Leibniz University's AI output is strongest in ML methodology, data-centric AI and knowledge-engineering, NLP, and trustworthy AI, giving the university a distinctive emphasis on the foundations and infrastructures of intelligent systems rather than single-sector applications.

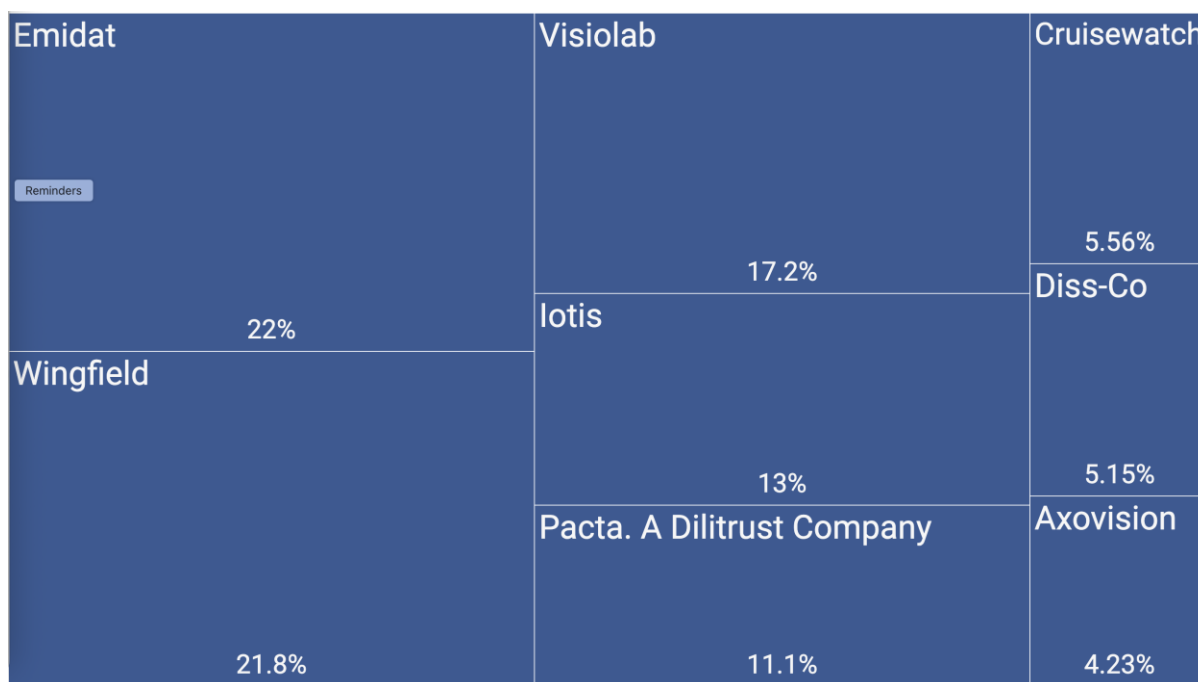
A solid position is held also by the **University of Göttingen**, which developed a robust AI research presence, particularly visible through groups such as the Neural Data Science Group, bridging machine learning and computational neuroscience and publishing on computer vision and large-scale data modelling. Additionally, the university recently highlighted a publication on generative AI and digital platforms, emphasising transformative mechanisms like intelligent automation, hyper-personalisation and collaborative innovation.

Moreover, the **Carl von Ossietzky University Oldenburg** places particular emphasis on applied AI, operating through its Chair of Applied AI and senior research groups that work on machine learning, human-machine interaction, and computational sustainability. A key research project, CoLDa (Collaborative Machine Learning for Data Value Creation), exemplifies the university's strength in federated learning, data integration and NLP applications in sensitive environments. These thematic concentrations position Oldenburg as a regional centre for AI in

University of Applied Sciences | Carl Von Ossietzky | Osnabrück | Technische Informationsbibliothek | University



Figure 17 – Key investments in startups in the AI and big data ecosystem in Lower Saxony



Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/crunchbase/ai-&-big-data.html>

When benchmarked against other German regions, Lower Saxony sits in an intermediate-to-strong position. It falls below the national leaders—Berlin, Munich and Baden-Württemberg—where the density of AI startups, research institutes, industrial AI investment and global visibility is considerably higher. Berlin attracts the bulk of German AI startup activity and talent inflow; Munich benefits from universities like TUM, LMU, the Munich Centre for Machine Learning and deep tech industry; Baden-Württemberg leverages the Tübingen AI Centre and large industrial firms such as Bosch, Porsche and Mercedes-Benz. Lower Saxony does not reach these levels of concentration or global attention. However, it is more competitive in AI than several other German states, including Schleswig-Holstein, Mecklenburg-Vorpommern, Rhineland-Palatinate and Saarland. Its strengths lie in the **synergy between engineering universities and globally integrated industries**, which gives it a depth of applied AI capability that many regions lack.

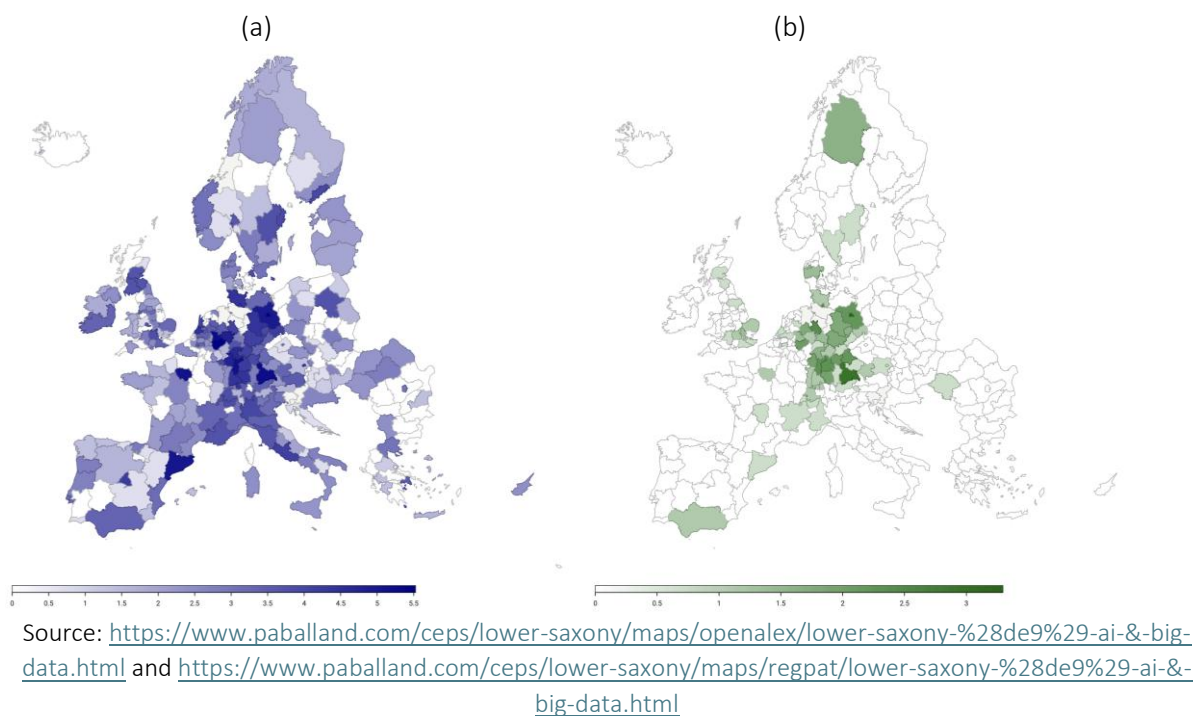
Internationally, Lower Saxony does not compete with the global AI powerhouses of the United States, China, the United Kingdom or the Paris region, where foundational AI research, large foundation-model companies and venture-backed AI labs dominate the landscape. Its relative competitiveness lies instead in domains where AI is closely tied to physical systems, manufacturing and energy. In these sectors, Lower Saxony can be considered internationally relevant, particularly in automotive and agritech AI. Yet it still lacks the scale, visibility and research concentration to influence the global AI frontier.

Overall, **the competitiveness of Lower Saxony in AI is defined by deep specialisation rather than broad leadership**. It is a region where AI is embedded into vehicles, machinery, agricultural equipment and energy systems, supported by universities with strength in data-centric and engineering-oriented machine learning. While it does not stand at the top of the global AI hierarchy, it possesses internationally credible niches and nationally competitive capabilities

that position it as a strong applied-AI region within Germany and a relevant contributor to Europe's industrial AI landscape.

That said, in the future, also in view of the upcoming implementation of the Apply AI Strategy at the EU level, **Lower Saxony should ensure it find itself ready to become a protagonist of the European effort to deepen AI into specific industrial ecosystems.** Figure 18 below shows the current network of collaborations between Lower Saxony and other regions of Europe when it comes to AI and big data. Both in terms of scientific publications (Figure 18a) and patents (Figure 18b), the linkages appear relatively well developed, with scientific collaborations being very strong within Germany but also spreading across Europe with peaks in Île-de-France, Central and Northern Italy, Catalunya, the Helsinki and Stockholm areas, all the way to Scotland and Greece. On patents, despite a more evident concentration within Germany, collaboration emerges with regions in Spain, France, the Netherlands, Sweden and Romania. Looking into these technological cooperations to consolidate meaningful links, and establish new links to ensure that Lower Saxony completes its technological readiness for the AI-led digital transformation will be very important for the years to come.

Figure 18 – Network of collaborations of Lower Saxony in the AI & big data domain, based on publications (a) and patents (b)



5.2 Autonomous and Connected Mobility

Lower Saxony occupies a pivotal and increasingly strategic position in the development of autonomous mobility in Germany and Europe as a whole. Anchored by the global headquarters and major manufacturing plant of Volkswagen in Wolfsburg, the region benefits from an ecosystem that integrates vehicle production, extensive supplier networks, logistics infrastructure and deep engineering expertise. Within this context, Volkswagen's software

subsidiary CARIAD SE has become a central force in the transition to software-defined vehicles, and its substantial activities in Wolfsburg and the broader Lower Saxony region signal a deliberate industrial shift from traditional internal-combustion manufacture to electric and autonomous mobility systems. The presence of major suppliers such as Continental Automotive—headquartered in Hanover—further reinforces the regional cluster for advanced driver-assistance systems (ADAS), sensor fusion, vehicle connectivity, and edge AI computing. These industrial capabilities are reinforced by academic and research institutions such as the Technical University of Braunschweig, which links AI, robotics, cyber-physical systems and metrological precision in vehicle innovation, and the Leibniz University Hannover with its data and AI research strengths through the L3S Research Centre.

In terms of infrastructure and logistics, Lower Saxony's deep-water port at Wilhelmshaven and the coastal automotive export sites of Emden and Cuxhaven provide a unique advantage for autonomous and connected vehicles, enabling a coherent supply-chain and export corridor that supports large-scale vehicle logistics, charging and servicing networks, and global-scale vehicle flows. The region also houses trial zones for autonomous driving, vehicle-to-everything (V2X) communication testbeds, and supplier workshops oriented to mobility services, thus creating an environment where R&D, pilot deployment and industrial scale-up coexist. The combination of manufacturing, mobility software, logistics infrastructure and engineering research gives Lower Saxony a competitive edge in autonomous mobility that is less reliant on consumer-platform disruption and more grounded in system-integration and industrial value chains.

Nevertheless, this position also entails challenges. While the region is strong in automotive and mobility manufacturing, it is somewhat less diversified in other forms of autonomous mobility such as micro-mobility, urban air mobility (UAM) or mobility-as-a-service (MaaS) ecosystems when compared with metropolitan regions such as Berlin or Munich, which host more startups, digital mobility platforms and venture capital flows. The concentration on large-vehicle manufacturing and supplier ecosystems means that innovation pathways that follow rapid software-driven disruption may compete less favourably than those regions more receptive to software-first mobility ecosystems.

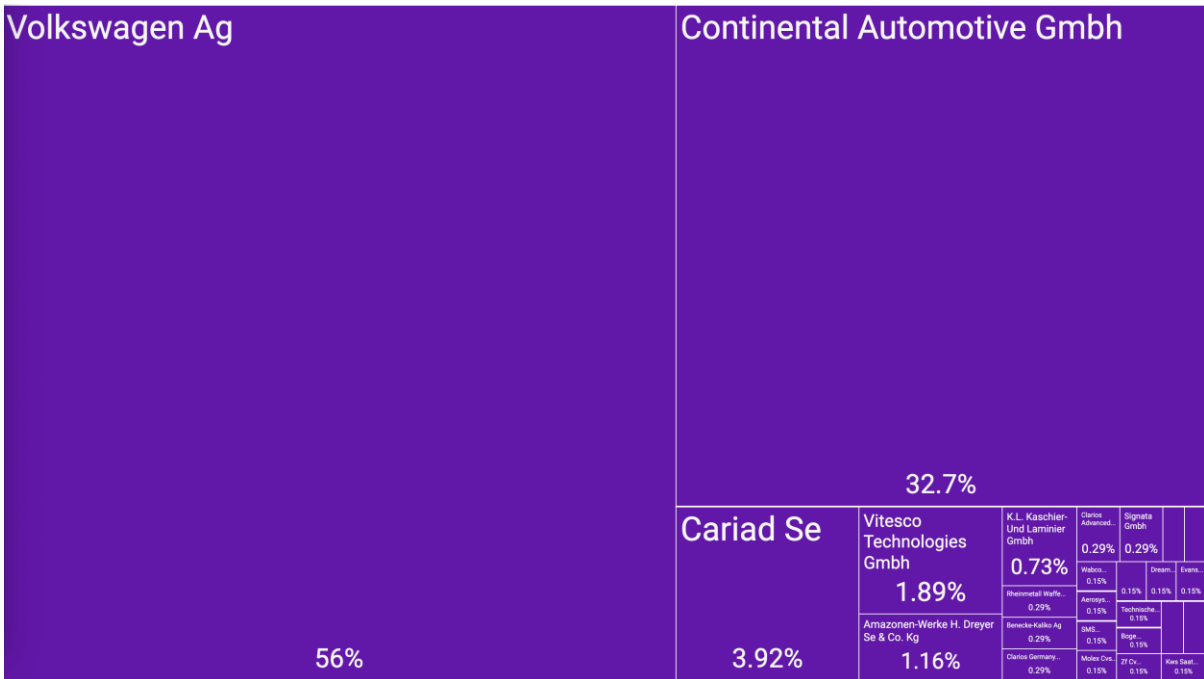
To maintain and enhance its competitiveness, Lower Saxony must envision **transitions that move beyond vehicle manufacture toward integrated mobility platforms, service-based models, data-driven mobility operations and cross-modal autonomy** (such as freight and logistics autonomy, air-ground integration, and smart infrastructure). The region's academic institutions and industry players need to strengthen **partnerships with startups, mobility-service platforms and global software ecosystems to keep pace with the shifting centre of gravity in autonomous mobility innovation**. Given the region's manufacturing heritage, logistics infrastructure and research anchor points, Lower Saxony is well-positioned to shape the next wave of autonomous mobility development—provided it embraces the full stack of connectivity, software, data services and mobility ecosystems, rather than focusing solely on vehicle production alone.

Figure 19 below shows the **predominant position of Volkswagen and Continental Automotive in the domain**, with a combined share of almost 90% of patents granted over the past five years

(which becomes more than 90% if Cariad is included). Volkswagen has built a substantial patent portfolio in autonomous and connected mobility, covering core technologies such as sensor fusion, computer-vision perception, and neural-network algorithms for object detection and driving-scene interpretation. Several patents focus on real-time decision-making, including lane-keeping, collision avoidance and automated manoeuvring based on multimodal sensor inputs. The company also protects innovations in connected-vehicle systems, particularly V2X communication, fleet-learning architectures and cloud-to-vehicle update pipelines that enable continuous improvement of automated-driving functions. Additional patents address efficient deployment of deep-learning models in embedded vehicle hardware, reflecting the shift toward software-defined mobility. Collectively, this portfolio demonstrates Volkswagen's strategic commitment to autonomous-driving intelligence, robust connectivity and scalable vehicle-software ecosystems. CARIAD SE, the software subsidiary of Volkswagen AG, has an expansive patent portfolio on perception and behaviour planning for automated driving by integrating camera, radar, lidar and ultrasonic data via deep-learning architectures; as well as cloud-to-vehicle learning pipelines that enable over-the-air updates for ADAS and autonomous-driving systems, as well as edge-AI infrastructures optimised for onboard decision-making.

On the other hand, Continental Automotive GmbH holds a broad patent portfolio in AI and connected mobility technologies, centred on embedded systems, sensor fusion and machine-learning-enabled vehicle components. Its patents cover areas such as autonomous-driving perception through neural-network-based object classification, adaptive driver-assistance algorithms, and in-vehicle edge-AI computing modules that dynamically allocate workloads between processors and cloud services. The company has also protected AI-enhanced cybersecurity frameworks involving anomaly-detection models for vehicle network monitoring, and human-machine interaction systems that interpret driver gestures, gaze and emotional cues.

Figure 19 – Key players in the autonomous and connected mobility ecosystem in Lower Saxony (patents)



Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/regpat/autonomous-&-connected-mobility.html>

When it comes to scientific publications, here the leading role is played by **TU Braunschweig**, with 29.1% of the publications. This is one of Lower Saxony’s strongest academic centres for applied AI, publishing extensively on machine learning for mobility, robotics, cyber-physical systems and safety-critical environments. Its Institute for AI in Interactive Systems focuses on causal ML, interpretable AI and intelligent interactive systems, while broader university research integrates AI into automated driving, sensor fusion and human–machine interaction. TU Braunschweig is also a key research partner in autonomous-vehicle projects such as the long-running “Stadtpilot,” which tested self-driving cars in real urban traffic.

Next, with 13.1% of publications, is **Leibniz University**, the leading AI research institution in Lower Saxony, which counts (together with TU Braunschweig) on a partnership with the **L3S Research Centre** that gives it national prominence in knowledge graphs, semantic technologies, large-scale data integration and trustworthy AI. The university’s AutoML and NLP groups are internationally visible, publishing on hyperparameter optimisation, reinforcement learning, sustainable ML and computational argumentation.

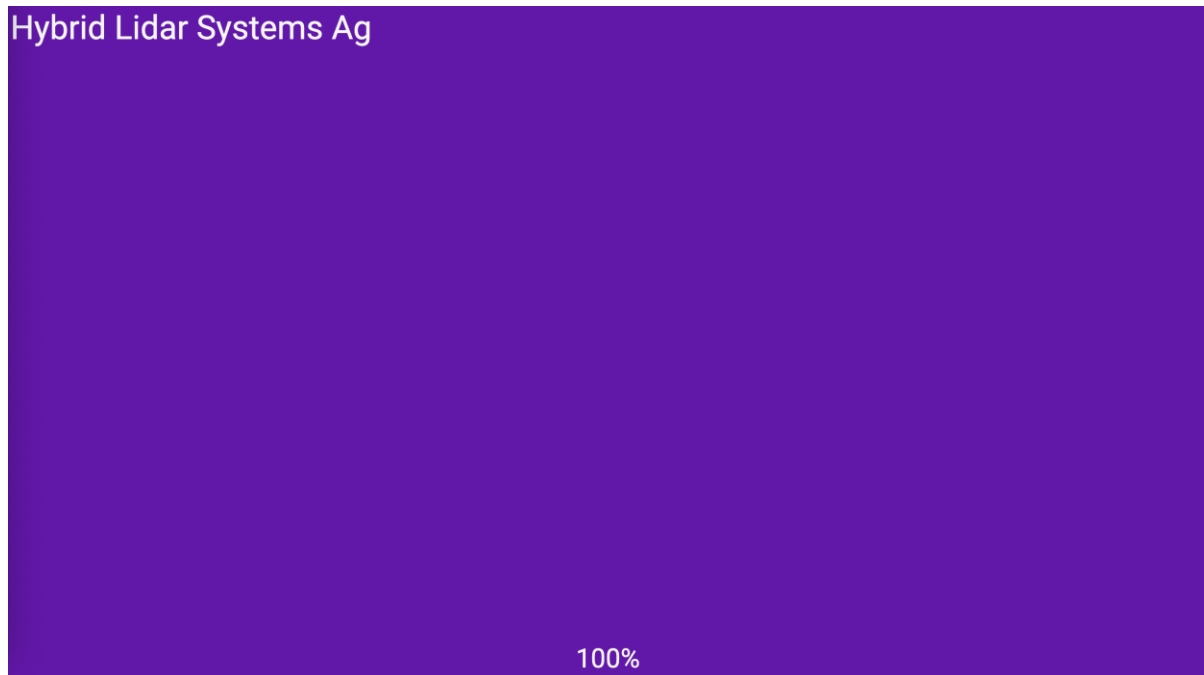
Figure 20 – Key players in the autonomous and connected mobility ecosystem in Lower Saxony (Publications)

Technische Universität Braunschweig (De) – 94509681	Volkswagen Ag	University Of Göttingen (De) – 74656192	Leuphana University Of Lüneburg (De) – 113456305	Ostfalia University Of Applied Sciences (De) – 2799859273											
	9.9%	4.5%	3.6%	3%											
	Clausthal University Of Technology (De) – 43980791	Oldenburger Institut FÜR Informatik (De) – 202367325	L3s Research Center (De) – 4210136150	Physikalisch- Technische Bundesanstalt (De) – 1285933455	University Of Hildesheim (De) – 155765044										
29.1%	5.4%	2.2%	2.1%	1.8%	1.7%										
	Continental Automotive Gmbh	Osnabrück University (De) – 170658231	Hochschule Osnabrück (De) – 4210159638	Hochschule Hannover (De) – 140025399	TUM (Germany) (De) – 421012239	Medizinische Hochschule Hannover (De) – 9409795	Leibniz University (De) – 155765044	Leibniz University (De) – 155765044	Leibniz University (De) – 155765044	Leibniz University (De) – 155765044	Leibniz University (De) – 155765044	Leibniz University (De) – 155765044	Leibniz University (De) – 155765044		
	5%	1.4%	0.7%	0.6%	0.6%	0.6%	0.4%								
Leibniz University Hannover (De) – 114112103	Carl Von Ossietzky Universität Oldenburg (De) – 129877168	Freihof Project Centre Wolfburg (De) – 4210141254	Institut für... (De) – 16777789	German Centre For Higher Education (De) – 16777789	Univ.- Leibniz (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789		
		1.2%	0.4%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%			
		1%	0.4%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%			
13.1%	4.8%	Max Planck Institute For Dynamics And Self-Organization (De) – 421008711	Freihof Project Centre Wolfburg (De) – 4210141254	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789	University Of... (De) – 16777789		
		0.8%	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%			
		0.8%	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%			

Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/openalex/autonomous-&-connected-mobility.html>

Importantly, venture capital investment in new startups has not been particularly active in the region over the past years. Our data report only one company in this domain, **Hybrid Lidar Systems AG**. This is a deep tech company based in Bad Salzdetfurth that develops patented solid-state flash LiDAR sensors (LiSSA) for automotive and industrial applications, using a hybrid time-of-flight and phase-shift measurement method to deliver high-resolution 3D sensing. The firm positions itself as a next-generation LiDAR supplier for autonomous vehicles, robotics and industrial automation, contributing directly to Lower Saxony's autonomous-mobility and sensor-technology ecosystem. In terms of financing, Hybrid Lidar Systems has raised several early-stage rounds, including a pre-seed and seed round totalling about €1.4 million between 2019 and 2020, followed by a Series A round of approximately €825,000 in July 2021, and more recently a €4.97 million EIC Fund grant in 2023, bringing total disclosed funding to roughly €7 million.

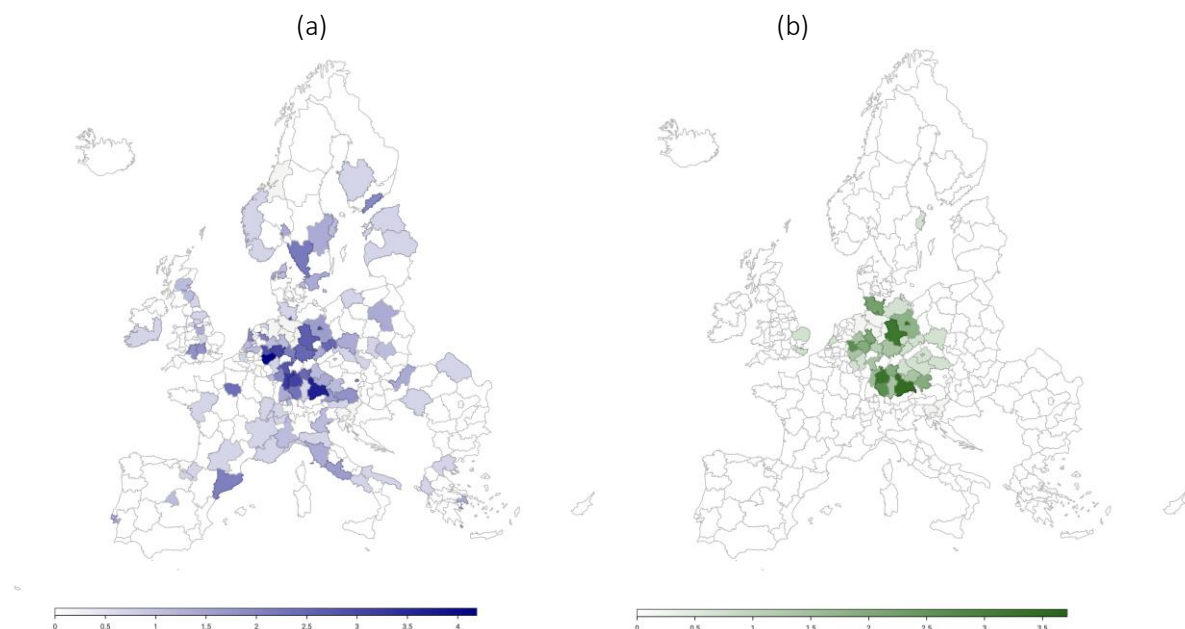
Figure 21 – Key investments in startups in the autonomous and connected mobility ecosystem in Lower Saxony



Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/crunchbase/autonomous-&-connected-mobility.html>

The network of collaborations of Lower Saxony in terms of scientific publications and patents is presented below, in Figure 22.

Figure 22 – Network of collaborations of Lower Saxony in the autonomous and connected mobility domain, based on publications (a) and patents (b)



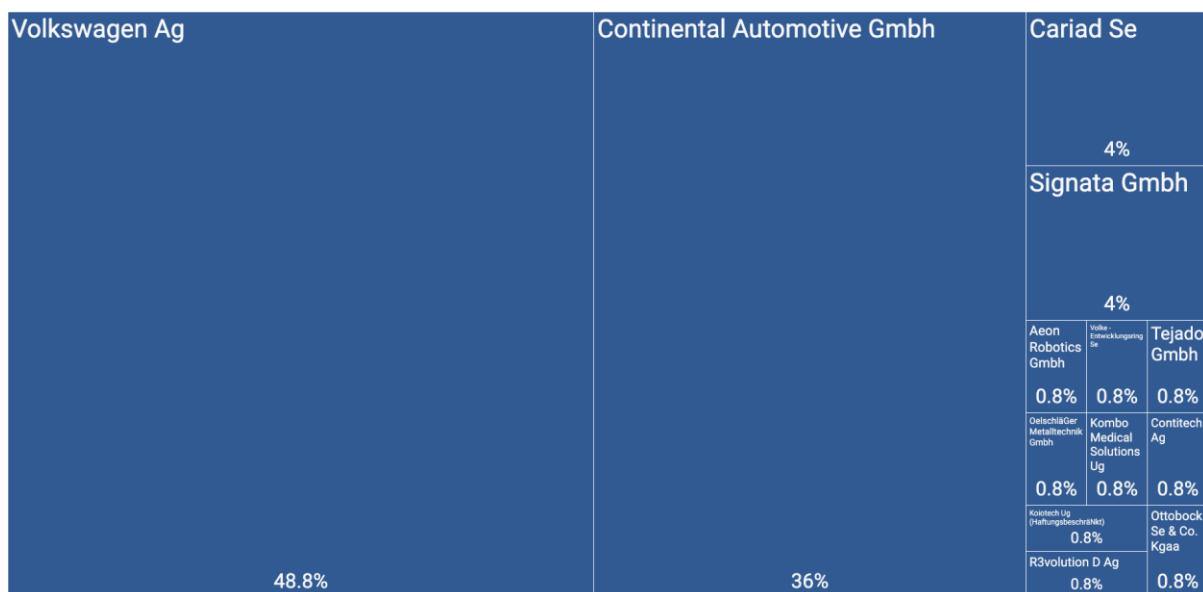
Source: <https://www.paballand.com/ceps/lower-saxony/maps/openalex/lower-saxony-%28de9%29-autonomous-&-connected-mobility.html> and <https://www.paballand.com/ceps/lower-saxony/maps/regpat/lower-saxony-%28de9%29-autonomous-&-connected-mobility.html>

5.3 Immersive Technologies

Lower Saxony has a developing but still relatively modest specialisation in immersive technologies, characterised by pockets of excellence rather than a fully formed regional cluster. The strongest activity is concentrated around Hannover and Osnabrück, where universities and applied-research institutes work on human–machine interaction, mixed-reality interfaces and simulation environments for training, mobility and industrial applications.

Volkswagen uses virtual-reality (VR) and augmented-reality (AR) tools extensively in vehicle development, design reviews, cockpit ergonomics and dealership showrooms. Virtual-prototype environments enable early testing of vehicle interactions, HUD (head-up-display) concepts and gesture interfaces. For instance, Volkswagen’s “ProdAnalysis VR” simulation system allows engineers to walk through assembly-line scenarios in immersive environments, though patent publications emphasise broader AI, sensor-fusion and autonomous-driving rather than immersive-only inventions. Similarly, Continental Automotive integrates AR/VR in its product development and manufacturing workflows—operator training in smart factories, digital twin simulations of tyre-machinery systems, and gesture-based controls for smart interiors. Some of its patents cover “operator assistance systems” that use a head-mounted display to highlight sensor-inputs and provide visual overlays. CARIAD, Volkswagen’s software subsidiary focused on software-defined vehicles, addresses immersive tech chiefly in the digital-cockpit and human–machine interface domain. It protects inventions in adaptive virtual displays, occupant-aware interfaces and simulation environments for testing autonomous-driving behaviour using virtual worlds. Despite these overlaps, immersive technology remains a supporting technology rather than a central specialisation; their patent and investment footprints still align primarily with autonomous mobility, connected vehicles, AI and software systems.

Figure 23 – Key players in the immersive technologies ecosystem in Lower Saxony (patents)



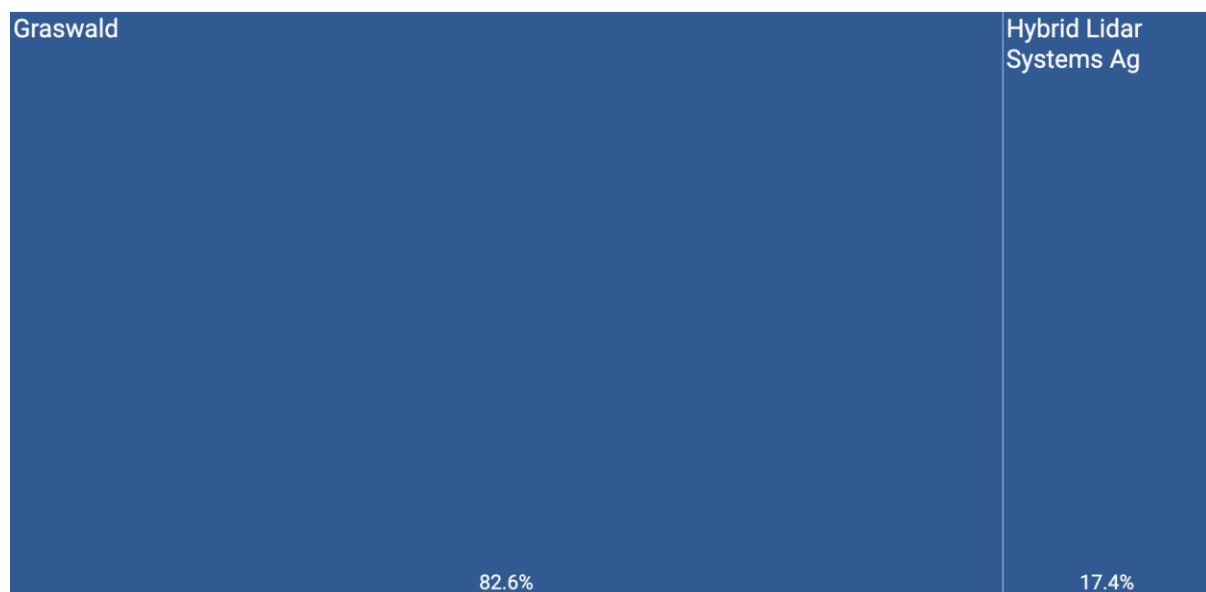
Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/regpat/immersive-technologies.html>

is limited, with few startups focused solely on AR/VR, and most activity arising from university spin-offs or applied-research projects rather than private investment.

Figure 25 below shows the two startups that received investment over the past years. Graswald and Hybrid Lidar Systems AG. **Graswald** announced a seed funding round of US \$3.3 million in March 2024, led by Lakestar and Supernode Global with participation from HTGF, FOV Ventures and other investors. (HTGF, 2024; The SaaS News, 2024). The company’s value proposition centres on automating the production of photorealistic 3D models from simple video input, dramatically lowering the cost and time required to produce immersive content for e-commerce, product visualisation and virtual/augmented-reality experiences (Graswald.ai, 2024). From a regional innovation perspective, this funding round places Graswald among the emerging German immersive-tech scale-ups, contributing directly to Lower Saxony’s capability in immersive interfaces, virtual content creation and spatial AI.

Hybrid LiDAR Systems AG, headquartered in Bad Salzdetfurth, specialises in developing solid-state flash LiDAR sensors using a patented “hybrid” measurement method integrating time-of-flight and phase-shift techniques, aimed at the automotive, mobility and industrial sensor markets (EU-Startups, 2024; Dealroom.co, 2025). According to Dealroom and related sources, the company secured an EIC Fund grant of approximately US \$4.97 million in 2023 to scale its sensor manufacturing and product development (Tracxn, 2025). Earlier angel and seed-stage investment rounds are reported, albeit with smaller disclosed amounts. (InvestNY, 2023). While LiDAR is not strictly an “immersive technology” in the sense of virtual-reality or augmented-reality content, these sensors are fundamental to spatial-mapping, perception and immersive interfaces in autonomous systems, robotics and mobility – thus positioning the company within the broader sensor-infrastructure layer that underpins immersive ecosystems. The investment therefore signals Lower Saxony’s strategic support of deep tech sensor firms that enable immersive mobility and automation applications.

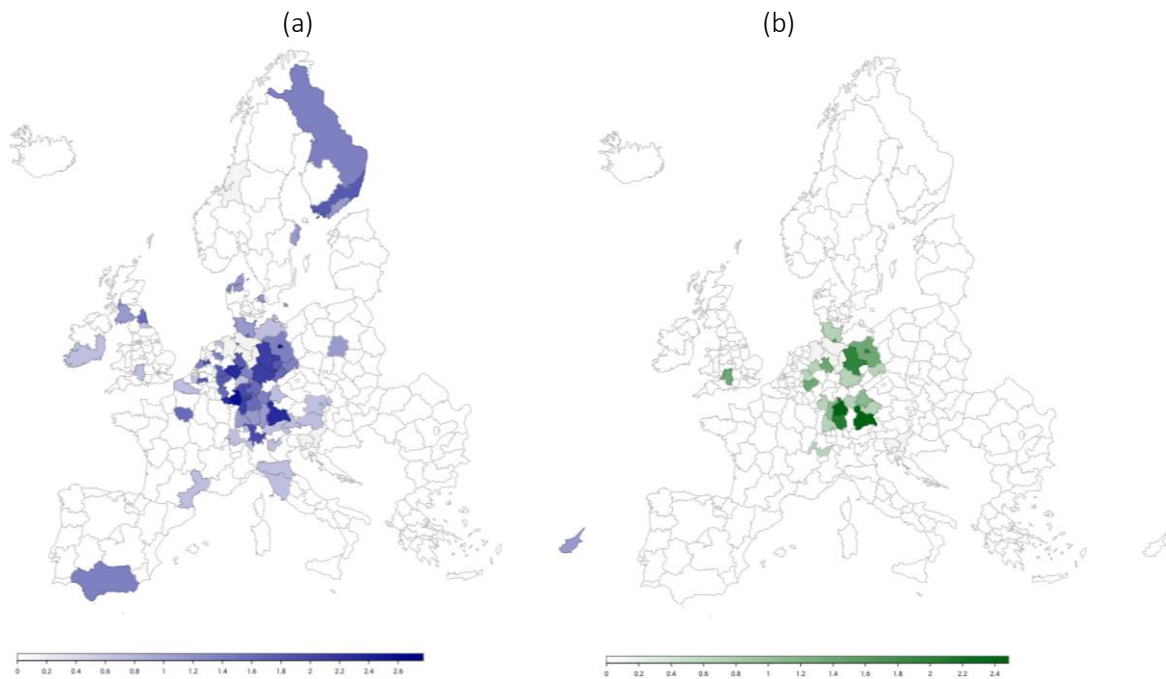
Figure 25 – Key investments in startups in the immersive technologies ecosystem in Lower Saxony



Source: <https://www.paballand.com/ceps/lower-saxony/ecosystems/crunchbase/immersive-technologies.html>

The network of collaborations of Lower Saxony in terms of scientific publications and patents in the immersive technologies domain is presented below, in Figure 26. As shown, while scientific collaboration extends beyond other regions in Germany, all the way to Finland, Cyprus, the UK and Spain, innovation cooperation leading to patents is confined to the territory of Germany, and one UK region (Gloucestershire, Wiltshire and the Bristol/Bath area).

Figure 26 – Network of collaborations of Lower Saxony in the immersive technologies domain, based on publications (a) and patents (b)



Source: <https://www.paballand.com/ceps/lower-saxony/maps/openalex/lower-saxony-%28de9%29-immersive-technologies.html> and <https://www.paballand.com/ceps/lower-saxony/maps/regpat/lower-saxony-%28de9%29-immersive-technologies.html>

Conclusion: Seizing Emerging Opportunities for Lower Saxony in a Changing Global Landscape

The long-term competitiveness of Lower Saxony depends on **its ability to transform its considerable scientific and industrial strengths into a more dynamic, internationally connected and investment-rich innovation ecosystem**. The diagnostic evidence in the report demonstrates that, while the region has deep capabilities in mobility technologies, engineering sciences, agrifood systems, biophotonics and elements of green technologies, these assets coexist with structural weaknesses in digital frontier technologies, venture-capital mobilisation and translational capacity between science and industry. Addressing these challenges requires a comprehensive and forward-looking policy framework that not only reinforces existing strengths but also confronts persistent bottlenecks that limit Lower Saxony's technological evolution.

The recommendations outlined here are grounded in the evidence of the CEPS analysis while extending beyond it by drawing on lessons from high-performing European regions such as Bavaria, Baden-Württemberg, North Holland, Copenhagen and the Stockholm-Uppsala corridor, as well as from international innovation leaders including South Korea, Ontario, Israel and selected U.S. states. Together, these reflections aim to support a strategic repositioning of Lower Saxony within the increasingly competitive landscape of green, digital, and deep tech innovation.

A central priority for policymaking is to **accelerate the development of digital general-purpose technologies and reinforce their integration into all regional industrial domains**. The report indicates that Lower Saxony's scientific production in fields such as AI, machine learning, robotics and automation is substantial, yet corresponding technological outputs measured through patents remain modest when compared to leading digital regions in Germany and Europe. The contrast between strong scientific capacities and weaker technological specialisation suggests that the translation mechanisms linking academic discovery to industrial innovation are not functioning with sufficient intensity or effectiveness. This diagnosis is supported by the evidence of **low venture-capital activity** in digital and AI-driven domains, the limited number of digital-native startups and the absence of a significant cluster of deep tech companies capable of commercialising AI-intensive solutions.

Strengthening the digital layer of the regional economy therefore requires **long-term investment in digital research infrastructures, including shared computing facilities, AI test beds, robotics laboratories and simulation platforms**. These infrastructures must be open not only to universities but also to SMEs and industrial actors, ensuring that digital capabilities diffuse across the regional economy rather than remaining concentrated within academic institutions. The most competitive regions in Europe have demonstrated that when digital infrastructure is widely accessible and accompanied by strong technology-transfer programmes, the rate of AI adoption in industry accelerates, enabling productivity gains and new value-creation pathways that reinforce competitiveness over time.

The development of digital capabilities cannot succeed, however, without **complementary action to strengthen the region's financial and investment environment**. A persistent theme in the report is the low volume of venture-capital investment flowing into Lower Saxony relative to other German Länder, which not only limits the growth of the startup ecosystem but also reduces the region's ability to retain high-potential innovations. In contrast, innovation-leading regions such as Bavaria and Berlin benefit from dense networks of venture-capital funds, corporate venture arms, specialised accelerators and scale-up financing mechanisms. **Lower Saxony's industrial actors, including those in the mobility, agrifood and manufacturing domains, constitute a potentially powerful base** for developing corporate venture-capital arms that could play a catalytic role in supporting early-stage companies, but such mechanisms remain underdeveloped.

A strategic recommendation is therefore to **establish a regionally anchored deep tech investment platform co-funded by public and private actors**, with the explicit aim of mobilising risk capital for frontier technologies including AI, robotics, advanced materials, greentech and medical technology. Public anchor investments can crowd in private capital by reducing

investor risk, but these mechanisms must be complemented by governance structures that ensure professional investment management and avoid political allocation of funds. International experience, particularly from the Nordic countries and Israel, shows that stable, professionally managed public-private investment platforms can substantially increase early-stage financing volumes and stimulate the emergence of high-growth technology clusters.

A further recommendation focuses on the need to strengthen translational structures that **bridge the gap between science and technology**. The report identifies several areas in which Lower Saxony has a strong scientific base but weaker technological realisation, including AI, biotechnologies, robotics and quantum-adjacent technologies. In these fields, universities and applied research institutions generate high-quality publications but lack sufficient industrial partners, translational institutes or technology-transfer agencies capable of transforming scientific results into commercially viable technologies. To address this imbalance, Lower Saxony could **establish dedicated translational institutes**, possibly modelled on leading European examples such as the IMEC in Belgium, SINTEF in Norway and VTT in Finland. These institutions play a vital role in connecting basic research with industrial application and are instrumental in the commercialisation of frontier technologies including semiconductors, photonics, advanced materials, biotechnology, cyber security and robotics. Lower Saxony already benefits from strong academic institutions, but the scale and organisation of its translational landscape could be significantly enhanced by creating mission-oriented centres that pool expertise and resources across institutions, thereby reducing duplication and supporting more ambitious long-term technological projects.

A complementary recommendation concerns the **internationalisation of Lower Saxony's innovation ecosystem**. The evidence presented in the report shows that the region's scientific and technological collaboration networks are heavily oriented towards national partners, with particularly strong ties to Berlin, North Rhine-Westphalia, Bavaria and Saxony-Anhalt. While these networks are valuable, they do not provide exposure to the full breadth of frontier innovation occurring in Europe and globally. International innovation leaders benefit from dense global networks linking academic institutions, high-growth companies, investors and public agencies. To enhance its international position, Lower Saxony should prioritise participation in major multinational research consortia, particularly those funded under Horizon Europe. It should also pursue bilateral partnerships with global innovation centres including the Netherlands, Denmark, Sweden, South Korea, the United States and Canada. Such partnerships could focus on joint research programmes, dual-institution doctoral training, bilateral innovation hubs, and reciprocal soft-landing platforms for startups seeking international market entry. Internationalisation should extend beyond universities to include SMEs, startups and industrial firms, all of which would benefit from integrated support programmes facilitating global R&D partnerships, technology demonstration abroad and participation in international regulatory, standardisation and certification frameworks.

The recommendations also address the importance of **strengthening human capital, talent attraction and skills development**. The green and digital transitions require a workforce with advanced competencies in computational sciences, cyber-physical systems, AI engineering, power electronics, robotics, biotechnology, sustainability management and cross-disciplinary problem solving. Although Lower Saxony has strong universities and applied science

institutions, the supply of highly skilled graduates is insufficient to meet the projected demand for digital and green specialists, and the region faces increasing competition for talent from metropolitan areas in Germany and abroad. Policies to expand doctoral training in strategic technological fields, develop industry-embedded postgraduate programmes and create international talent-attraction schemes are therefore crucial. These efforts should be complemented by reskilling and upskilling initiatives aimed at the existing workforce, particularly in sectors facing rapid technological change such as automotive manufacturing, agrifood industries and energy systems. Global experience shows that regions adopting proactive skills strategies can mitigate labour-market disruptions associated with technological transitions while stimulating innovation in strategic sectors.

A further dimension concerns the evolution of Lower Saxony's industrial base. The region's innovation landscape is heavily influenced by large incumbent firms, particularly in the mobility, manufacturing and agrifood sectors. While these firms are central to the region's strengths, they may also slow the pace of technological diversification if they do not sufficiently invest in frontier innovation. Ensuring that industrial transformation supports rather than inhibits innovation requires **policies that encourage incumbents to adopt new technologies, invest in R&D and develop collaborative innovation models with startups and academic institutions. Cluster policies can play a significant role here.** Establishing stronger thematic clusters in areas such as sustainable mobility, applied AI, precision agriculture, photonics, climate technologies and advanced manufacturing would provide a platform for shared research agendas, common infrastructure, joint training programmes and coordinated investment. European evidence demonstrates that cluster development accelerates innovation diffusion, reduces fragmentation and enables SMEs to benefit from collective resources that would be inaccessible individually. Clusters must be designed as open innovation systems with active participation from startups, SMEs, research institutions, public agencies and large industrial anchors.

Another recommendation centres on the **strengthening of the region's regulatory and testing environment.** Frontier technologies in mobility, including autonomous vehicles, advanced driver-assistance systems and connected infrastructure, require sophisticated regulatory sandboxes and large-scale testing environments. Similarly, precision agriculture, robotics, AI-enabled medical technologies and advanced energy systems benefit from test beds that allow real-world experimentation under controlled conditions. Lower Saxony should therefore invest in an integrated network of regulatory sandboxes and test beds that accelerate technology validation and reduce barriers to market entry. These facilities should be interoperable, open and aligned with European standards to ensure that innovations developed in the region can scale beyond local markets. Germany's leading automotive regions have demonstrated that supportive regulatory frameworks combined with advanced testing environments accelerate industrial transformation by fostering early adoption and de-risking deployment.

The **policy environment must also address issues of institutional coordination and governance.** The report identifies fragmentation across science, technology and investment layers, indicating that regional priorities are not always aligned or systematically pursued. A recommendation is to establish a high-level strategic council for science, technology and innovation, composed of representatives from academia, industry, government and the

investment community. This council would be responsible for setting strategic priorities, ensuring coherence across policy domains, monitoring technological trends and evaluating the performance of innovation initiatives. Such bodies exist in leading innovation regions and serve as mechanisms for long-term planning, cross-sectoral coordination and evidence-based policy monitoring. The council should operate with a clear mandate to align resources, evaluate impact and provide guidance on emerging opportunities in green and digital transitions.

In addition to the structural recommendations, targeted measures are needed to improve specific technological domains. In mobility technologies, **Lower Saxony should double down on its strengths in autonomous and connected systems by expanding research into sensor technologies, digital twins, edge computing and AI-enabled vehicle intelligence.** Efforts should also focus on diversifying the industrial base to include software-defined vehicles, smart infrastructure and mobility services. In the agrifood domain, the region has strong potential to develop a leading position in precision agriculture, robotics and digital farm-management systems. Supporting the integration of AI, sensing and automation technologies in agricultural practices can increase productivity and sustainability. In the life-science sector, the region would benefit from reinforcing its strengths in **medical technologies and biophotonics**, while also expanding translational capabilities in **biotechnology and biomanufacturing**. In climate technologies, increased emphasis should be placed on frontier research and innovation in **energy-storage systems, carbon-capture technologies, hydrogen, fusion and next-generation renewable systems.**

Finally, while this report intentionally presents our data analysis with minimal contextualisation, **in reality the opportunities and challenges that Lower Saxony faces for the future cannot be analysed in isolation, without placing them in the current geopolitical and European context.** In particular, the current geo-political situation and the new priorities being set by the European Commission are extremely relevant for the future of Lower Saxony. The Clean Industrial Deal, the Rearm Europe initiative, the proposal for FP10, the future R&I programme of the EU post-2028, the Apply AI Strategy and the new agenda on technological sovereignty are only some examples of a series of developments that open up new opportunities for Lower Saxony to consolidate and relaunch its competitiveness. This, however, requires enhance situational awareness of what is happening in Brussels and beyond; good analytics backing Lower Saxony's proposed role in specific investment and programmes (e.g. in the "CERN for AI"); and openness to deeper cross-regional cooperation with other European regions with related technological specialisation.

Taken together, these recommendations articulate a **long-term strategy for transforming Lower Saxony into a more vibrant, diversified and internationally competitive innovation ecosystem.** The region has the scientific depth, industrial capacity and institutional foundations to succeed, but future competitiveness depends on the speed and coherence with which policies are implemented. The green and digital transitions present unprecedented opportunities for technological leadership, but these opportunities will only materialise if Lower Saxony invests strategically, strengthens its innovation governance, deepens international engagement and cultivates a dynamic startup ecosystem. The recommendations outlined here constitute a framework for ensuring that the region moves decisively towards a more innovative, resilient and globally connected future.

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Methodological Appendix

Data. The empirical foundation of this study rests on three large-scale datasets. Patent data come from the OECD REGPAT database, covering European and international patent documents from 2010 to 2024. Scientific publications are sourced from OpenAlex, which provides a comprehensive coverage of global research output from 2010 to 2025. Startup investment data are taken from Crunchbase Pro, covering venture funding and deal flows between 2010 and 2025. All three datasets are reclassified into 48 Key Strategic Technologies using a bespoke machine learning and expert validation process, described below.

Classification. The classification of technologies into patents, scientific topics, and investment categories follows a three-step methodology designed to maximise robustness and reproducibility. The first step involves embedding a clean list of descriptive keywords for each technology into 3,072-dimensional vectors using advanced language models. The same embedding process is applied to all CPC patent classes and all OpenAlex scientific topics. By computing cosine similarity between vectors, we generate candidate matches. This approach captures semantic similarity beyond literal wording, ensuring that linguistically different terms that denote the same concept, such as “3D printing” and “additive manufacturing,” are mapped together. The second step refines this candidate list using measures of relatedness. Whereas embeddings capture semantic proximity, relatedness ensures that the similarity is meaningful in empirical innovation systems. Relatedness is computed from the normalized co-occurrence of CPC codes within the same patent, of topics within the same publication, or of technologies within the same funded startup. This step prevents spurious semantic matches by anchoring classifications in actual technological, scientific, and investment networks. The third step is a systematic manual review, during which we examine candidate matches, apply thresholds, and remove false positives. This is particularly important for technologies with fuzzy boundaries such as artificial intelligence or synthetic biology, whereas more codified fields like nuclear fission are less ambiguous. The final outcome is a robust crosswalk between technologies and classification systems. Unlike keyword searches or regex-based methods, which require exhaustive lists of terms and often miss synonyms or return irrelevant results, this approach combines semantic precision with empirical validation.

Indicators. To assess competitiveness, three composite indices were developed. The Technological Index aggregates patent counts, per capita intensity, revealed comparative advantage (RCA), and relatedness density. The Scientific Index combines publication counts, per capita intensity, RCA, and relatedness density. The Investment Index brings together startup funding, per capita intensity, RCA, and relatedness density. Each index is scaled from 0 to 100, balancing both absolute and relative performance. These indices allow us to place Lower Saxony's technologies into quadrants that distinguish between global leadership, scientific leadership, technological leadership, and lagging areas. Relatedness density quantifies how easily a region could branch into a new technology based on the presence of related activities in its existing portfolio (see formula as described in Balland, 2017 and the EconGeo R package). Complexity captures how exclusive or sophisticated a technology is,

based on its distribution across urban areas as a variation of the scaling method proposed by Balland et al. 2020).

Limitations. There are several methodological limitations that should be acknowledged. Patent data capture tangible inventions and underrepresent service-led inventions. Scientific publication data do not fully capture industrial research and may be influenced by country-specific publication practices. Startup investment data are skewed towards fields with high venture capital intensity and therefore underestimate mature technologies that are not VC-driven. These caveats underline the importance of careful interpretation of results and expert validation of the optimal investment allocations.

Appendix – Link to Interactive Graphs

To access the menu of interactive graphs, use the QR code below, or click [this link](#).

