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Critical and Emerging Technologies Index 2025: France Report

General Overview

- **France ranks 9th overall**, among the 25 countries evaluated in the Critical and Emerging Technologies Index, **in line with its global GDP rank of 7th.**
- Relatively to other assessed countries, **France has a competitive edge on 3 technological areas: Artificial Intelligence (6th), Quantum (7th), Space (5th).** In these 3 domains, France stands out as a European leader. From a global standpoint, it appears as a prominent "small country", often performing strongly compared to its size. Yet, it is still lagging tech superpowers such as the US and China with significantly lower scores across metrics.
- France's most significant weakness is its underperformance in **Semiconductors (12th)**, where it scores below the average of the 26 studied countries and regional blocs. This gap is particularly concerning given that semiconductors are a foundational technology with broad implications across other critical technological domains. France is also underperforming on **Biotechnologies (12th)** compared to what historical trends could have predicted.

Cross-Sector Recommendations

As an overall strategy, France needs to continue building its advantage on quantum, AI, and space. The situation is differentiated on biotechnologies and semiconductors.

- **Biotechnologies used to be a strength of France with leading companies such as Sanofi**[1], but, as the French Council for Economic Analysis stated: "France suffers from a series of malfunctions in

1 Laure Millet, "France : the Land of Healthcare Innovation?", *Institut Montaigne*, June 15, 2021, France: the Land of Healthcare Innovation? | Institut Montaigne

the pharmaceutical field, which have caused it to lose places in the international race for innovation." France needs to fix its deficiencies (decreasing public R&D support in health, lack of cooperation between universities and industry, etc. - *more detail provided in the dedicated "Biotechnologies" section*).

- **Semiconductors have never been a strength in France.** This sector is a strategic priority in itself but it is also a crosscutting enabler that could potentially bottleneck leadership on other technologies. Here, conversely to biotechnologies, France needs to build on its unique strengths that seem underexploited (notably the existence of a robust cooperation between academia and industry - *more detail in the dedicated "Semiconductors" section*).

In relation to policy levers, it is delicate to summarize one-size-fits-all recommendations but, based on the analysis of the key bottlenecks, levers include:

- **Reinforcing the cooperation between universities and industry/startups, for example through technology transfer offices**. According to World Bank's "R&D University-Industry Collaboration" ranking, France ranks 48th in 2022, whereas the United States, China, South Korea, Germany or the United Kingdom (countries that rank higher in the overall CET index) occupy the 1st, 5th, 14th, 16th and 22nd positions respectively.[2]
- **Addressing the venture capital gap** (particularly in late-stage funding) between tech powerhouses and France thanks to the investments of national incumbents (given that France lacks global big tech companies) and public purchasing, particularly in the context of increasing defence expenditures following the Ukraine-Russia war.
- **Sustaining industrial policy efforts.** The France 2030 initiative (France's €54 billion plan to catch up on critical technologies) is a good starting point but needs to be amplified and renewed beyond 2030, to sustain recently revitalized industrial policy efforts.
- Continue creating a **pro-innovation environment** with simplified regulatory processes when needed (simplifying or consolidating regulatory approval avenues, creating 'fast-tracks', etc.).

Artificial Intelligence

France is a rising AI leader with world-class talent and startups but must urgently scale up compute capacity.

France ranks 6th in the ranking of the CET Index. This ranking is consistent with other benchmarks:

- **Stanford AI Vibrancy Index.** In this index, France ranks 4th in 2023 behind the US, China and the UK (when focusing on R&D, Education, Economy and Infrastructure dimensions).[3]
- **2024 Global AI Index.** France ranks 5th in this index, behind the US, China, the UK and Singapore, rising quite dramatically from a 10th position back in 2021.[4]

2 World Bank," Global Innovation Index", accessed April 2025, Dataset Detail | Prosperity Data360 | Prosperity Data360

3 Stanford University HAI, "Which countries are leading in AI?", accessed April 2025, Which countries are leading in AI? | Stanford HAI

4 Tortoise Media, "The Global AI Index", accessed April 2025, The Global AI Index

France's AI success is based on 5 main pillars:

- **A vibrant ecosystem of startups**, spearheaded by startups such as Mistral AI (€6Bn valuation), Hugging Face (€4.3M billion valuation), Dataiku (€3.5 Billion valuation). French AI startups raised 1.9 Bn in 2024.[5] Nevertheless, in the Generative AI race, France (and more generally Europe) mainly rely on one unique player: Mistral AI.[6]

- **Top-tier academic talent**. France is consistently identified as a top-3 nation in terms of AI education, alongside the US and the UK, in the Staford HAI AI Index.[7] The country has identified 9 AI research "clusters", supported by 360 million of funding. Every year, more than 40,000 students specialize in AI, with an objective to raise this number to 100,000 per year.[8] World-class talent being key, France is also proactively attracting international talents through the French Tech Visa and a dedicated "Choose France for Research" team, to help the most talented researchers to settle in France.[9]

- **Abundant, low-carbon energy supply**. With AI's energy demands rapidly rising, France's energy mix offers a strategic advantage, with an electricity mix composed of more than 70% of nuclear energy and being 95% decarbonized. In 2024, the country recorded a **net electricity export surplus of +89 TWh**, boosting its position as an energy-secure AI hub.[10] In a recent analysis, CSIS notes that "France aims to leverage surplus nuclear power to attract data centers and support AI research centers across the country."[11]

- **A strong public support**. A first national AI strategy had been established in 2017, already putting France in the race. Since then, 2,5 billion € of public funding has been channeled towards AI, as part of the France 2030 investment roadmap.[12] As announced by French President Emmanuel Macron during the 2025 AI Action Summit in Paris, France is planning to attract €109 billion of private investments in the coming years[13] including major investments by the UAE.

Yet, **France's strong position on AI is weakened by a lack of compute capabilities**, which is one of the three essential components of the "AI triad"[14] (algorithms, compute, talent). As a remedy, France needs to invest in publicly-owned supercomputers (such as the Jean Zay supercomputer, France's biggest supercomputer, with a cumulated power of 125,9 Petaflop/s) and support the development of data centers. In March 2025, during

5 French Government, "Faire de la France une puissance de l'IA", accessed April 2025, https://www.info.gouv.fr/upload/media/content/0001/13/62923d5690a5f4ec6812ab1a5efdde17fddca67b.pdf

6 Abboud, Leila, and Tim Bradshaw. "Has Europe's Great Hope for AI Missed Its Moment?". *Financial Times*. January 30, 2025. Has Europe's great hope for AI missed its moment?

7 Stanford University HAI, "Which countries are leading in AI?", accessed April 2025, Which countries are leading in AI? | Stanford HAI

8 French Government, "IA : une nouvelle impulsion pour la stratégie nationale", accessed April 2025, IA : une nouvelle impulsion pour la stratégie nationale | info.gouv.fr

9 French Government, "IA : une nouvelle impulsion pour la stratégie nationale", accessed April 2025, IA : une nouvelle impulsion pour la stratégie nationale | info.gouv.fr

10 French Government, "Faire de la France une puissance de l'IA", Accessed April 2025, https://www.info.gouv.fr/upload/media/content/0001/13/62923d5690a5f4ec6812ab1a5efdde17fddca67b.pdf

11 Girishankar, Navin, Joseph Majkut, Cy McGeady, Barath Harithas, and Karl Smith. "Securing Full Stack U.S. Leadership in AI." *CSIS*. Accessed May 13, 2025. Securing Full Stack U.S. Leadership in AI

12 French Government, "La stratégie française en intelligence artificielle", published October 2024, La stratégie française en intelligence artificielle | enseignementsup-recherche.gouv.fr

13 French Government, "La stratégie française en intelligence artificielle", published October 2024, La stratégie française en intelligence artificielle | enseignementsup-recherche.gouv.fr

14 Ben Buchanan, "The AI Triad and What It Means for National Security Strategy." 2023. *Center for Security and Emerging Technology*. June 7, 2023. The AI Triad and What It Means for National Security Strategy | Center for Security and Emerging Technology

the AI Summit, the government identified 35 ready-to-use datacenter-friendly sites.[15] Supporting emerging national cloud players such as Scaleway, Outscale ou OVH, will be needed to foster alternatives to foreign cloud giants.

Biotechnologies

France ranks 12th in the CET index ranking on Biotechnologies. This is tied as the lowest ranking among the five dimensions. This score underlines a mixed performance of France on biotechnologies, despite being a historical leader in this domain. In a recent report by the Center for Strategic and International Studies (CSIS) entitled "Renewing French Pharmaceutical Innovation—Lessons for the U.S." the authors note: "For France, once a global leader in pharmaceuticals, the COVID-19 pandemic has exposed how far the fortunes of a once leading industry has declined. [...] France is the last country among those on the United Nations Security Council to offer a COVID-19 vaccine of its own."[16]

On the bright side:

- **France remains a European leader in research.** In March 2024, the EU Joint Research Center (EU JRC) noted that "Germany and France have the highest number of biotech patent applicants in the EU, accounting for over half of all EU biotech patents."[17]
- **Its biotech industry is vibrant.** France can notably count on Sanofi, a global "big pharma" company. But it can also count on a large network of smaller biotech companies: according to the **OECD key biotechnology indicators**, in 2022, France was ranking 3rd on the "Number of Firms active in Biotechnology," with 1,803 biotech firms (versus 1,953 in Canada and 2,840 in the US).

On the darker side:

- **France is underperforming on vaccine research and production**. In a 2021 note entitled "The Lifecycle of Pharmaceutical Innovation: France is Lagging Behind", the French Council of Economic Analysis[18] (an independent, non partisan advisory body reporting to the French Prime Minister) noted that, during the Covid-19 crisis: "The unfruitful search for a vaccine, albeit originally a French invention, has shown the country's struggle to keep up the pace in this race for innovation." It points at a decreasing public R&D funding for health[19], a weak cooperation between universities and industry and complex regulatory processes.[20]

15 French Government, "IA : une nouvelle impulsion pour la stratégie nationale", accessed April 2025, IA : une nouvelle impulsion pour la stratégie nationale | info.gouv.fr

16 Alexandre Kersten, Benjamin Glanz, "Renewing French Pharmaceutical Innovation-Lessons for the U.S.: Perspectives on Innovation." *CSIS*. August 17, 2022. Accessed April 13, 2025, Renewing French Pharmaceutical Innovation—Lessons for the U.S. | Perspectives on Innovation | CSIS

17 European Commission Joint Research Center, "The global landscape of biotech innovation: state of play", published March 20, 2024, The global landscape of biotech innovation: state of play - European Commission

18 Conseil d'Analyse Économique

19 In France, "*public R&D funding for health is almost half of Germany's and has decreased by 28% between 2011 and 2018, whereas it increased by 11% in Germany and 16% in the United Kingdom over the same period*". Source: Pharmaceutical Innovation: How Can France Catch Up?

20 Authors note that the "multiplicity of institutional players in France makes procedures more complex and lengthens the timeframes, particularly those for launching reimbursable innovations. This can ultimately have negative consequences on research and innovation." Source: Pharmaceutical Innovation: How Can France Catch Up?

- **Private investment** appears as a major default according to several studies[21]: "Fewer start-ups are financed (117 in 2019 against 135 in the United Kingdom); lower amounts are allocated (average ticket of 9 million euros in France against 12 million in the United Kingdom and 16 million in Germany); and the share of French biotechs in the European landscape is decreasing."[22]

- **While being performant on red biotech (healthcare/pharma), France performs relatively poorer on other dimensions**, particularly green biotech (agriculture-related). In a EU JRC study[23], researchers analyzed the performance of countries along different types of biotechnologies: agriculture-related (green biotech), industry-related (white biotech) healthcare/pharma-related (red biotech) and horizontal biotech (biotechnologies with transversal uses). They concluded that France has a **robust specialization in red biotech (healthcare/pharma-related) but performs poorer in green biotech.** This is consistent with France's low score on agriculture-related biotech in the CET index (for context, the cultivation of GMOs for commercial purposes has been banned in France since 2008, which quite naturally leads to France's low score on those aspects).

Quantum Technologies

France is a rising quantum powerhouse but must accelerate industrial scale-up to turn scientific excellence into global leadership.

France is one of the forerunning countries in Quantum Technologies, **ranking 6th** on this dimension. This position stems from a combination of industrial, academic, and policy strengths.

- France is home to **world-class national champions** such as "Pasqal" and "Alice et Bob", two quantum computing unicorns (valued over $1Billion). According to recent estimates, French quantum startups raised more than €350 million, which makes France the leading European country in terms of fundraising and the third globally, behind the US and Canada.[24]

- **Academic excellence.** France benefits from world-class universities and scientific talent, which form the backbone of its quantum innovation ecosystem. It is in the top 5 of the countries with the highest "Number of universities ranked in the Top 100 for quantum computing."[25]

- **Strong public support.** A National Quantum Strategy was designed in 2019, with 1Bn of public funding over 4 years, for a total of €1.8 billion of public-private funding combined.[26] This strategy outlines that this sector will create 16,000 jobs by 2030 and represent between 1% and 2% of French exports.

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21 Tania Rabesandratana, "After coronavirus vaccine failures, France laments the state of its biomedical R&D", *Science*, April 21, 2021, After coronavirus vaccine failures, France laments the state of its biomedical R&D | Science | AAAS

22 Margaret Kyle, Anne Perrot, Pharmaceutical Innovation: How Can France Catch Up?", *Notes du Conseil d'Analyse Économique* (no. 62), January 2021, Note du CAE nº 62 (anglais)

23 European Commission Joint Research Center, "The global landscape of biotech innovation: state of play", published March 20, 2024, The global landscape of biotech innovation: state of play - European Commission

24 French Government, "France 2030 : Point d'étapes trois ans après le lancement de la stratégie nationale des technologiques quantiques et lancement du programme Proqcima", accessed April 2025, https://www.info.gouv.fr/upload/media/content/0001/09/d6afa78052f892351fa83b14dd66344d26f03e7a.pdf

25 François Candelon, Jean-François Bobier, Maxime Courtaux, and Gabriel Nahas, "Can Europe Catch Up with the US (and China) in Quantum Computing?", The Boston Consulting Group, August 25, 2022, Can Europe Catch Up with the US (and China) in Quantum Computing? | BCG

26 Direction Générale des Entreprises, "France 2030 : stratégie nationale pour les technologies quantiques", published July 06, 2023, accessed April 2025, France 2030 : stratégie nationale pour les technologies quantiques | Direction générale des Entreprises

To achieve this, France aims at doubling PhD graduates in this field. It dedicates 120M€ to support entrepreneurship (Series A, B and C) and 350M€ to the industrial deployment of those solutions.[27]

- **Notable milestones were already achieved, with 350 useful qubits already operational in March 2024, demonstrating substantial progress in this critical technology** and the ambition to reach 2000 qubits within the coming 2 years.[28] The French government notably launched the PROQCIMA program (inspired from the British program ULTRA during World War 2), with the ambition of having 2 quantum computer prototypes with 128 qbits by 2032.

Yet, France is trailing significantly other quantum superpowers, including the US, China, or Canada. In a 2022 analysis entitled "Can Europe Catch Up with the US (and China) in Quantum Computing?", the BCG Henderson Institute noted that France was lacking "the type of private investments that enable quantum computing startups to scale in the US, which is a venture capital powerhouse" but also "big digital players—such as Google, Amazon, and IBM—that have the power to consolidate the quantum sector."[29] It also notes that "after some promising steps—such as the French Innovation Defense Agency's funding of the quantum computing startup, Pasqal—there has been almost no military interest in quantum computing in the EU."[30]

To preserve its strong start, France needs to bridge the investment gap:

- France needs to attract more international funding (the BCG Henderson Institute notes that "the EU attracts less than 2% of overall investment in its quantum computing startups from the US, whereas Canada has attracted around 20%"[31], attributing part of the problem to tight foreign investment controls).
- While early-stage funding is robust, France needs more quantum-focused venture funds and private equity firms on late stage financing.

France also needs to develop a quantum market, through public purchase (for example, through partnerships with Defense players, particularly in the context of increasing defense expenditures) and partnerships with French national incumbents.[32]

27 Direction Générale des Entreprises, "France 2030 : stratégie nationale pour les technologies quantiques", published July 06, 2023, accessed April 2025, France 2030 : stratégie nationale pour les technologies quantiques | Direction générale des Entreprises

28 French Government, "France 2030 : Point d'étapes trois ans après le lancement de la stratégie nationale des technologiques quantiques et lancement du programme Proqcima", accessed April 2025, https://www.info.gouv.fr/upload/media/content/0001/09/d6afa78052f892351fa83b14dd66344d26f03e7a.pdf

29 François Candelon, Jean-François Bobier, Maxime Courtaux, and Gabriel Nahas, "Can Europe Catch Up with the US (and China) in Quantum Computing?", The Boston Consulting Group, August 25, 2022, Can Europe Catch Up with the US (and China) in Quantum Computing? | BCG

30 François Candelon, Jean-François Bobier, Maxime Courtaux, and Gabriel Nahas, "Can Europe Catch Up with the US (and China) in Quantum Computing?", The Boston Consulting Group, August 25, 2022, Can Europe Catch Up with the US (and China) in Quantum Computing? | BCG

31 François Candelon, Jean-François Bobier, Maxime Courtaux, and Gabriel Nahas, "Can Europe Catch Up with the US (and China) in Quantum Computing?", The Boston Consulting Group, August 25, 2022, Can Europe Catch Up with the US (and China) in Quantum Computing? | BCG

32 The Henderson Institute notes that "because the EU lacks large digital companies, national incumbents must play a key role in supporting and scaling the quantum ecosystem.", in its analysis Can Europe Catch Up with the US (and China) in Quantum Computing? | BCG

Semiconductors

France ranks 12th in the CET index ranking on Semiconductors.

France is performing poorly on the dimensions assessed in the index (Assembly and Testing (OSAT), Equipment, Manufacturing, Chip Design and Tools, Raw Materials and Wafers, etc.).

Nevertheless, France can count on STMicroelectronics, a French-Italian joint venture company and Europe's largest semiconductor manufacturing and design firm. In 2022, France unveiled its 2030 Electronics Strategy[33], as part of a "return of industrial policy", consistent with recent analysis.[34] As part of this strategy, 2.7 billion of this funding package was used to support the building of a 7.5 billion mega-fab plant in Crolles (near Grenoble) by STMicroelectronics and U.S.-based GlobalFoundries to double production capacities in France, with production officially starting a year later, in June 2023.[35] The facility location is no surprise: it is situated in the Grenoble region, characterized by a unique concentration of expertise and players, where French semiconductor companies (STMicroelectronics, Loitec) and research centers (Center for Atomic and Alternative Energies) cooperate. The Center for Strategic and International Studies recognized the strength of the French cooperative model in its recent paper "The French Model for Cooperative Semiconductor Research: Lessons from CEA-Leti".[36] This unique feature needs to be leveraged to reinforce France's position in the semiconductor value chain.

Space Technologies

France is the leading "small country" in space technologies globally but needs to adapt in response to the rise of disruptive "New Space" players.

Putting aside space superpowers (US, Russia, China), France is the leading "small" country in Space technologies, **ranking 5th** on this dimension in the 2025 edition of the CET Index. Several factors contribute to this robust position:

- **A solid industrial heritage, based on historic investments, along the space tech value chain** (access to space, launch capacities, space equipment, etc.). France can rely on global champions such as Airbus Defence and Space (world-class aerospace company), Thales Alenia Space (second-largest commercial provider of modules for the ISS and largest satellite manufacturer in Europe) and Ariane Group. Together, they form a tightly knitted and consistent ecosystem of interoperable companies.
- **A long history in space with the third-oldest space agency** behind NASA (USA) and Roscosmos (Russia): the Centre National D'Etudes Spatiales (CNES), created in 1961. As reported by a March 2024 report by the Center for Strategic and International Studies (CSIS) about "The Evolution of

33 Direction Générale des Entreprises, "France 2030 : stratégie electronique", published October 18, 2024, France 2030 : stratégie électronique | Direction générale des Entreprises

34 Mathieu Duchâtel, "Semiconductors in Europe: the return of industrial policy", *Institut Montaigne*, March 2022, Semiconductors in Europe: the return of industrial policy

35 Direction Générale des Entreprises, "France 2030 : stratégie electronique", published October 18, 2024, France 2030 : stratégie électronique | Direction générale des Entreprises

36 Shivakumar, Sujai, Charles Wessner, and Thomas Howell. n.d. "The French Model for Cooperative Semiconductor Research: Lessons from CEA-Leti." *CSIS*. February 16, 2024. Accessed April 13, 2025. The French Model for Cooperative Semiconductor Research: Lessons from CEA-Leti

French Space Security", "CNES had the largest budget of any civil space agency in Europe."[37]

- The existence of a domestic **launch capability on French soil** (Kourou launch base, in French Guiana).
- **A marked ambition of developing space defense capabilities**: as reported by a 2024 CSIS report on "The Evolution of French Space Security", "France is the only European country that has openly discussed its intent to develop defensive counterspace capabilities, and since the election of French president Emmanuel Macron in 2017, the nation has elevated the strategic importance of military space operations in its overall defense strategy."[38] This is consistent with the strong score of France on the "Security" sub-dimension of its Space score.

Despite this strong foundation, France needs to adapt to the fast-evolving space ecosystem. Innovative space ventures such as SpaceX and the increasing role of private sector alongside States are the symptoms of a wider revolution called "New Space" (reconfiguration of the space industry from primarily government-led programs to a vibrant ecosystem driven by private companies and commercial interests, characterized by faster cycles of innovation, cost reduction, re-usability and miniaturization of space technologies).[39] In this sense, startups such as SpaceX have undeniably disrupted the traditional space industry, outpacing conventional European launchers. To reinforce the space industry and not fall behind, in March 2025, French Prime Minister ordered a national strategy for space.[40]

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37 Makena Young, "The Evolution of French Space Security", *Center for Strategic and International Studies*, March 2024, 240314_Young_French_Space.pdf

38 Makena Young, "The Evolution of French Space Security", *Center for Strategic and International Studies*, March 2024, 240314_Young_French_Space.pdf

39 Gahyun Helen You, "The Final Frontier", *Foreign Policy*, May 19, 2022, The Final Frontier – Foreign Policy

40 French Government, "Stratégie Spatiale nationale", accessed April 2025, Stratégie spatiale nationale | info.gouv.fr

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Critical and Emerging Technologies Index 2025: Germany Report

Executive Summary

Germany ranks 7th out of 26 in the CET index. The German legacy industrial base is dominated by precision engineering and traditionally focused on continuous incremental innovation. Mechanical and chemical engineering as well as biotechnology stand out in particular. Even though Germany's research institutions produce competitive fundamental research across various fields, German industry struggles to transform that into more disruptive applications. As a result, Germany lacks high-tech disruptors. The most notable systemic challenges include slow regulatory adaptation, an aging workforce, talent drain and attraction, a high bureaucratic burden, and high energy prices. Venture capital is limited due to a traditionally risk-averse financial culture and legacy industries that historically had a limited need for growth capital. Major industrial strategies are successfully starting to address these issues.[1]

Cross-Sector Recommendations

- **Secure long-term public funding** for Germany's strong foundational research ecosystem.
- **Ease high bureaucratic burdens**, such as lengthy market approval processes, data privacy protocols, and bureaucratic visa procedures for foreign talent.
- **Address the talent development, retention, and attraction crisis**: Expand public STEM education funding, ease tech immigration pathways, lower language requirements, emphasize low cost-of-living in international recruiting (to counter relatively low salaries).
- **Foster industry-academia collaboration**: Strengthen technology transfer offices at universities, expand public-private innovation ventures (SPRIN-D), and fund tech start-up accelerators at public universities.

1 This piece has been informed by off-the-record exchanges with industry experts, policymakers, and researchers in Germany.

- **Strengthen startup support**: Attract venture capital through tax incentives and grants, building on the success of the German Future Fund. Improve effectiveness of scaling capital through mechanisms like accelerated depreciation and loss carryovers.
- **Create investor confidence in long-term energy prices** by accelerating the energy transition.

General Overview

Overall, Germany ranks 7th out of the 26 nations and regional blocs analyzed in the CET index. As Europe's largest economy, Germany is a leading innovation hub in Europe, investing 3.13% of its GDP in R&D in 2022 and is on track to 3.5% in 2025.[2] Germany's relative investment is among the highest worldwide, compared to 3.59% in the U.S., 3.41% in Japan, 2.91% in the UK, and 2.23% in France in 2022.[3]

Germany's economic and technological strengths are rooted in precision engineering and a culture of continuous optimization. This approach of incremental, rather than disruptive, innovation has brought about strong legacy industries in mechanical and chemical engineering, as well as biotechnology. A long-standing, well-funded public university system underpins Germany's excellence in fundamental research. However, the past three decades of particularly disruptive innovations globally, mainly in the digital and computing domains, have been challenging for Germany.

While its industry is beginning to catch up, significant systemic challenges remain, such as slow regulatory adaptation, an aging workforce, talent drain and attraction, a high bureaucratic burden, and high energy prices.[4] Startups face the additional challenge of comparatively limited availability of venture capital due to a risk-averse financial culture and legacy industries that historically had a limited need for growth capital.[5]

Major policy initiatives are starting to address these issues, such as the SPRIN-D agency for disruptive innovations[6], the €10 billion German Future Fund to mobilize venture capital,[7] and targeted industrial strategies for AI, quantum technology, space, and green tech—tied together under the High-Tech Strategy 2025.[8]

Germany performs relatively strongly across all technologies analyzed: artificial intelligence (4rd), biotechnology (6th), semiconductors (8th), space (8th), and quantum (5th). The following sections dive deeper into each of them.

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2 Germany – Country of Innovation," German Missions in the United States, accessed May 14, 2025, https://www.germany.info/us-en/2427156-2427156.

3 "Bulk Data Download Service," UNESCO Institute for Statistics, accessed April 5, 2025, https://apiportal.uis.unesco.org/bdds.

4 *Innovationsindikator 2023*, Bundesverband der Deutschen Industrie e.V. and Roland Berger, accessed April 5, 2025, https://www.innovationsindikator.de/fileadmin/innovationsindikator/downloads/Innovationsindikator-2023.pdf; *Artificial Intelligence in Germany: Status Quo, Opportunities and Options for Economic Policy Measures*, KfW Research, accessed April 4, 2025, https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-Dateien/Fokus-2024-EN/Focus-No.-463-June-2024-AI.pdf.

5 "The Future of Venture Capital Funds in Germany," Beaumont Capital Markets, accessed May 6, 2025, https://beaumont-capitalmarkets.co.uk/the-future-of-venture-capital-funds-in-germany/; "Investment Activity in German Venture Capital Market Is Better Than Sentiment," KfW, accessed May 6, 2025, https://www.kfw.de/About-KfW/Newsroom/Latest-News/Pressemitteilungen-Details_796288.html; *Venture Capital Market Study 2023*, PwC, accessed May 6, 2025, https://www.pwc.de/en/deals/venture-capital-market-study.html.

6 *Evaluation der SPRIND GmbH – Executive Summary*, Fraunhofer-Institut für System- und Innovationsforschung ISI, accessed April 5, 2025, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/p/2025/2024_01_28_SPRIND_Executive_Summary.pdf.

7 "The Future of Venture Capital Funds in Germany," Beaumont Capital Markets, accessed May 6, 2025, https://beaumont-capitalmarkets.co.uk/the-future-of-venture-capital-funds-in-germany/.

8 *Federal Government Report on the High-Tech Strategy 2025*, Federal Ministry of Education and Research (BMBF), accessed April 5, 2025, https://www.bmbf.de/SharedDocs/Publikationen/DE/FS/657232_Bericht_zur_Hightech-Strategie_2025_en.pdf; *Artificial Intelligence Strategy of the German Federal Government – Update 2020*, Federal Government of Germany, accessed April 4, 2025, https://www.ki-strategie-deutschland.de/files/downloads/Fortschreibung_KI-Strategie_engl.pdf; "Germany – Quantum Computing," International Trade Administration, accessed April 4, 2025, https://www.trade.gov/market-intelligence/germany-quantum-computing.

Artificial Intelligence

Status Quo

Germany's strengths in AI lie in industrial application, autonomous systems, and data privacy as well as a strong foundational research system with deep historical roots. The country has yet to see major success in commercial AI development and is failing to attract investments from global players. The comprehensive regulatory environment may offer opportunities for innovation.

Strengths: Germany's Saarland played a pivotal role in the early days of foundational AI research, driven by the German Research Center for AI, the Max Planck Institute for Informatics, and the Fraunhofer AI center. Thus, it exceeds the rest of Europe in the number of AI patents. Other strengths include industrial application of AI, autonomous systems (esp. vehicles), and data privacy.[9] Comprehensive EU and national legislation with an emphasis on privacy, security, and trust provide regulatory clarity and the most consumer-friendly AI policy framework globally.

The federal government has declared AI a major industrial policy priority as a cross-industry accelerator, marked a €5 billion ($5.5 billion) National AI Strategy, the AI Observatory, and expansion of Fraunhofer AI Centers.[10]

Challenges: Germany has no major players in consumer-facing AI or global AI startups. In the face of insufficient venture and growth capital, this is unlikely to change. The talent drain is particularly prevalent in the industry due to uncompetitive salaries. Domestic AI development lags far behind global players and is dependent on foreign computing infrastructure. Major US AI companies focus their European investments on Paris and London. While forward-looking, the regulatory environment is viewed as burdensome in the industry.[11]

Recommendations

- **Double down on the European regulatory framework** by making human-centered, trustworthy, and private AI Germany's/Europe's comparative advantage. Iterate the framework by identifying points of friction for industry and innovation while maintaining the emphasis on transparency, robustness, and data governance.
- **Solidify leadership in AI industry application** by identifying best practices and facilitating cross-industry exchanges. Accelerating AI diffusion into Germany's industrial base, esp. SMEs, allows the economy to profit from AI more broadly, stirring inclusive growth.
- **Expand AI startup funding via tax incentives and targeted growth capital subsidies**. Tailored fiscal instruments, such as loss carryovers, would help promising firms overcome scaling bottlenecks

9 *Artificial Intelligence in Germany: Status Quo, Opportunities and Options for Economic Policy Measures*, KfW Research, accessed April 4, 2025, https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-Dateien/Fokus-2024-EN/Focus-No.-463-June-2024-AI.pdf; *OECD Artificial Intelligence Review of Germany*, OECD Publishing, accessed April 4, 2025, https://www.oecd.org/en/publications/oecd-artificial-intelligence-review-of-germany_609808d6-en.html.

10 *Artificial Intelligence Strategy of the German Federal Government – Update 2020*, Federal Government of Germany, accessed April 4, 2025, https://www.ki-strategie-deutschland.de/files/downloads/Fortschreibung_KI-Strategie_engl.pdf.

11 *Artificial Intelligence in Germany: Status Quo, Opportunities and Options for Economic Policy Measures*, KfW Research, accessed April 4, 2025, https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-Dateien/Fokus-2024-EN/Focus-No.-463-June-2024-AI.pdf; *OECD Artificial Intelligence Review of Germany*, OECD Publishing, accessed April 4, 2025, https://www.oecd.org/en/publications/oecd-artificial-intelligence-review-of-germany_609808d6-en.html.

and retain IP within Germany. Leverage the German Future Fund to boost capital mobilization.

- **Invest in AI supercomputing infrastructure in a joint European effort**, including sovereign cloud environments and scaled model training capacity. This would reduce reliance on US hyperscalers and enable sovereign training and operation of large models.
- **Reduce bureaucratic friction for foreign talent to join the workforce** by simplifying visa processes, prioritized visa categories, and industry-specific allocations.

Biotechnologies

Status Quo

Germany has a long tradition of biomedical research and development, characterized by a mix of large legacy companies and disruptive innovators.

Strengths: Germany's biotechnology sector is dominated by drug development marked by a combination of global industry giants, like Bayer, Merck, and Boehringer Ingelheim, and innovators, such as BioNTech, that have put the country at a world-leading position in mRNA. Additional strengths include cancer immunotherapies and advanced diagnostics.[12] This is underpinned by a world-leading foundational research ecosystem, made up of Max Planck and Fraunhofer Institutes as well as public universities, sustained through public funding.

Challenges: Growth capital for startups is limited due to a risk-averse financial culture and a limited need for it historically[13], leading to early acquisitions by industry giants before major market disruption.[14] A heavy bureaucratic burden slows down clinical trial approvals—particularly compared to France and the UK—and difficulties attracting foreign talent. The foundational research output could be leveraged more effectively for private sector innovation.

Recommendations

- **Increase R&D tax incentives to improve startups' liquidity**, lowering the need for growth capital. Enhanced tax credits and loss carryovers would make early-stage biotech ventures more resilient and attract private investment at critical phases.
- **Streamline clinical trial approvals**, especially for early-stage and high-impact therapies. Accelerated timelines would erase the competitive disadvantage from prolonged delays until commercial market entry.
- **Sustain funding for the foundational research ecosystem, while establishing technology**

12 "Medical Biotechnology Industry," Germany Trade & Invest (GTAI), accessed April 5, 2025, https://www.gtai.de/en/invest/industries/healthcare-market-germany/medical-biotechnology.

13 "The Future of Venture Capital Funds in Germany," Beaumont Capital Markets, accessed May 6, 2025, https://beaumont-capitalmarkets.co.uk/the-future-of-venture-capital-funds-in-germany/; *Venture Capital Market Study 2023*, PwC, accessed May 6, 2025, https://www.pwc.de/en/deals/venture-capital-market-study.html.

14 "BioNTech's Covid-19 Vaccine Success Sparks Investments in German Biotech," *Wall Street Journal*, May 10, 2021, https://www.wsj.com/articles/biontechs-covid-19-vaccine-success-sparks-investments-in-german-biotech-11620644401.

transfer offices and expanding biotech incubators at universities. This would smoothen the commercialization pipeline for Germany's existing research excellence.

- **Reduce bureaucratic friction for foreign talent to join the workforce** by simplifying visa processes, broader recognition of international qualifications, and prioritized visa categories.

Semiconductors

Status Quo

Germany's semiconductor industry has fallen behind the rapid innovations of the past decades. Recent developments created momentum for manufacturing expansion but there is still no clear pathway for domestic cutting-edge chips.

Strengths: "Silicon Saxony" is Europe's largest microelectronics hub with 3,600 companies and 76,000 employees,[15] expanding rapidly through major recent investments in new plants by Intel (€30 billion / $33 billion) and TSMC (€10 billion / $11 billion) or Infineon's €5 billion ($5.5 billion) expansion. This strengthens Europe's capacity and independence in mass semiconductor production.

Challenges: Germany's semiconductor industry is focused largely on the manufacturing of "mid-tech" chips with a complete lack of sub-10nm fabrication. The economies of scale needed to be competitive in the industry make market entries challenging. Thus, there is a lack of domestic companies focused on cutting-edge chip development. The chip production itself is heavily reliant on subsidies and strained by high energy prices and talent shortages.[16]

Recommendations

- **Offer a clear roadmap for the long-term future of semiconductor subsidies**, ensuring predictability for firms and investors. A multi-year framework with transparent criteria and post-2027 funding clarity would safeguard planned investments and avoid project delays amid shifting budgetary conditions.
- **Pursue a joint European effort to attract cutting-edge semiconductor manufacturing**, particularly sub-10nm nodes. Coordinated incentive packages, shared infrastructure investment, and strategic alignment with critical partners like France, the Netherlands, and Italy would reduce intra-EU subsidy races, while strengthening European high-tech autonomy.
- **Provide targeted support for public universities to strengthen teaching and expertise in the field**, including specialized degree programs and professorships as well as lab partnerships with industry. Expanding microelectronics education would address severe talent shortages and stir a domestic ecosystem and innovation.

15 "Semiconductor Industry in Germany," Germany Trade & Invest (GTAI), accessed April 5, 2025, https://www.gtai.de/en/invest/industries/industrial-production/semiconductors; "Top Investments of the Year: Saxony Is Becoming a Global Venue for the Semiconductor Industry," Germany Trade & Invest (GTAI), accessed April 5, 2025, https://www.gtai.de/en/invest/business-location-germany/fdi/top-investments-of-the-year-saxony-is-becoming-a-global-venue-for-the-semiconductor-industry-1075990.

16 "No Subsidies? No TSMC," *fDi Intelligence*, August 29, 2024, https://www.fdiintelligence.com/content/54330be8-0a4c-5bdf-b83a-0ddcf8274c16.

Space Technologies

Status Quo

Germany is building new momentum in space marked by achievements such as the first Isar Aerospace launch in March 2025, the ongoing construction of the German Offshore Spaceport, and increased government interest in space independence.

Strengths: Germany's strengths in space stem from a strong legacy aerospace sector, particularly satellite systems and manufacturing, space situational awareness, and launch innovations. These are driven by major industry players like Airbus Defence and Space and OHB SE as well as a scientific research core led by the German Aerospace Center (DLR). A new wave of startups, most notably Isar Aerospace and Rocket Factory Augsburg, drive innovations such as small launch vehicles and lead the push toward European launch independence.

Challenges: Few industries are as closely linked and dependent on government programs and objectives as space. Thus, insufficient coordination between the German National Programme for Space and Innovation (NPWI) and the European Space Agency (ESA) as well as the EU Space Program lead to redundancies and a lack of clear priorities—providing an uncertain environment for long-term private investors. This is exacerbated by the absence of a German National Space Law that would clarify operational and regulatory frameworks, such as liability or launch requirements, unlike in France or the UK.[17] While limited space defense capabilities create risk for operators of space assets, their future development also presents business opportunities.

In 2023, the federal government released a National Space Strategy, emphasizing commercialization, ESA cooperation, space security, and space sustainability.[18]

Recommendations

- **Pass a national Space Law**, offering regulatory and operational clarity. This would streamline licensing, liability, and insurance requirements for private space activities, reducing uncertainty for startups and investors.
- **Expand public-private partnerships for startups and guarantee long-term public contracts**. Stable demand from public procurement would de-risk private investment and enable firms to scale domestically.
- **Push German leadership in ESA projects and integrate industrial space policy with key European partners** by taking lead roles in flagship missions and coordinating industrial emphases with France, the UK, and Italy. Closer coordination would reduce duplication, strengthen joint supply chains, and boost European autonomy.
- **Foster talent pipelines through increased public funding for aerospace engineering** at public

17 *Global Outer Space Guide: Germany*, Norton Rose Fulbright, February 2024, https://www.nortonrosefulbright.com/en/knowledge/publications/582a6d62/global-outer-space-guide-germany.

18 *The German Federal Government's Space Strategy*, Federal Ministry for Economic Affairs and Climate Action (BMWK), accessed April 5, 2025, https://www.bmwk.de/Redaktion/EN/Publikationen/Technologie/the-german-federal-governments-space-strategy.html.

universities and academic partnerships with industry clusters. This would help address long-term workforce gaps and accelerate applied research.

Quantum Technologies

Status Quo

In quantum technologies, Germany is leveraging its precision engineering capabilities to provide crucial components and industrial machinery, while being held back by the talent drain, a lack of capital, and limited interest by legacy industries in quantum technologies.

Strengths: Precision engineering excellence helped Germany to lead globally in quantum sensors and photonics as well as supplying industrial machinery for the production of specialized quantum technologies—with a startup scene focused on these topics. Quantum-secured communication is another strength. Strategic public private partnerships are bringing cutting-edge quantum computing to Germany, most notably Fraunhofer Institute's partnership with IBM (Quantum System One, Europe's first superconducting quantum computer) and an Infineon/eleQtron collaboration developing quantum processor units. This is complemented by a strong foundational research ecosystem.[19]

Germany's federal government views quantum as a cross-industry accelerator, similar to AI. The €3 billion Quantum Action Plan offers research grants and industry subsidies across the field.[20]

Challenges: Despite progress, Germany is lagging behind the US and China in scaling usable quantum computers. Public private partnerships cannot fill the gap left by a lack of venture capital. Uncompetitive salaries fuel the talent drain in quantum as well. Further challenges include the translation of foundational research into practical applications and limited interest/creativity within the legacy industries to apply quantum technologies.

Recommendations

- **Extend Quantum Action Plan funding beyond 2026**, ensuring continuity for long-horizon R&D and hardware development. Stable support would avoid project fragmentation and signal long-term commitment to public and private actors alike.
- **Foster quantum talent pipelines through stronger quantum clusters at public universities**, including specialized degree programs and professorships as well as partnerships with industry.
- **Offer quantum training to experienced engineers to encourage new quantum applications in the legacy industries**. Upskilling programs in collaboration with industry associations would expand near-term use cases and bridge Germany's industrial base with emerging quantum capabilities.
- **Reduce bureaucratic friction for foreign talent to join the workforce** by simplifying visa processes, prioritized visa categories, and industry-specific allocations.

19 "A Brief Overview of Quantum Computing in Germany," *The Quantum Insider*, April 11, 2023, https://thequantuminsider.com/2023/04/11/a-brief-overview-of-quantum-computing-in-germany/; "Germany – Quantum Computing," International Trade Administration, accessed April 5, 2025, https://www.trade.gov/market-intelligence/germany-quantum-computing.

20 *Handlungskonzept Quantentechnologien*, Bundesministerium für Bildung und Forschung (BMBF), April 2023, https://www.bmbf.de/SharedDocs/Publikationen/DE/5/31822_Handlungskonzept_Quantentechnolgien.pdf.

Governance Structure

Responsibilities for emerging technologies are spread across several ministries and agencies, with no centralized executive body. The Federal Ministry of Education and Research and the Federal Ministry for Economic Affairs and Climate Action lead public R&D and industrial innovation policy, respectively. They are independent bodies but coordinate planning. In 2019, Germany established a Federal Agency for Disruptive Innovation (SPRIN-D), focused on supporting specific high-potential ideas through public-private partnerships. Initial evaluations have found its impact to be effective and promising.[21]

The federal government has launched large programs aimed at accelerating the modernization and diversification of Germany's technological industrial base, prioritizing AI (€5 billion AI strategy), quantum technology (€3 billion quantum action plan), space (National Space Strategy), and green tech—tied together under the High-Tech Strategy 2025.[22] The German Future Fund is proving successful in closing the venture capital gap to its peers.[23]

Some governance gaps remain. Germany lacks a national innovation council or cabinet-level coordination mechanism, such as Japan's CSTI or Korea's PACST, to set strategic priorities across sectors. Thus, limited alignment of cross-sector goals, strategic frameworks, and funding reduces the system's responsiveness.

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21 *Evaluation der SPRIND GmbH – Executive Summary*, Fraunhofer-Institut für System- und Innovationsforschung ISI, accessed April 5, 2025, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/p/2025/2024_01_28_SPRIND_Executive_Summary.pdf

22 *Federal Government Report on the High-Tech Strategy 2025*, Federal Ministry of Education and Research (BMBF), accessed April 5, 2025, https://www.bmbf.de/SharedDocs/Publikationen/DE/FS/657232_Bericht_zur_Hightech-Strategie_2025_en.pdf;
Artificial Intelligence Strategy of the German Federal Government – Update 2020, Federal Government of Germany, accessed April 4, 2025, https://www.ki-strategie-deutschland.de/files/downloads/Fortschreibung_KI-Strategie_engl.pdf; "Germany – Quantum Computing," International Trade Administration, accessed April 5, 2025, https://www.trade.gov/market-intelligence/germany-quantum-computing.

23 The Future of Venture Capital Funds in Germany," Beaumont Capital Markets, accessed May 6, 2025, https://beaumont-capitalmarkets.co.uk/the-future-of-venture-capital-funds-in-germany/.

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Critical and Emerging Technologies Index 2025: Italy Report

Executive Summary

Italy ranks mid-tier among the 26 nations and regional blocs investigated in the Critical and Emerging Technologies Index, trailing key EU peers like Germany and France but ahead of many other neighbors.

In advancing its capabilities, Italy can leverage the large resources of the EU Recovery Fund[1] as well as the recent European alignment on unprecedented investments to strengthen the defense ecosystem (ReArm Europe Plan[2]).

From the following analysis, few common insights emerge on what Italy must do:

- Institutionalize pathways from lab to market to convert intellectual leadership into global competitiveness.
- Mobilize higher private capital to scale innovation and sustain long-term tech competitiveness.
- Invest in both strategic infrastructure and human capital to gain autonomy and global influence in frontier technologies.

To address the gaps, Italy could follow the successful models of Germany's SPRIND[3] and the US's DIUx[4], by initially strengthening the Deep-Tech division of Cassa Depositi e Prestiti (CDP) with the ultimate plan to establish an ad-hoc agency focused on advancing dual-use emerging technologies. Such a framework would foster dual-use technologies, driving disruptive growth in academia, industry, and government.

1 European Commission, *Italy's Recovery and Resilience Plan*, May 2025, https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/italys-recovery-and-resilience-plan_en

2 European Commission, *White Paper on European Defence and the Rearm EU Plan for Readiness 2030*, May 2025, https://defence-industry-space.ec.europa.eu/eu-defence-industry/introducing-white-paper-european-defence-and-rearm-europe-plan-readiness-2030_en.

3 Federal Ministry of Education and Research (Germany), *Federal Agency for Disruptive Innovation – SPRIND*, May 2025, https://www.bmbf.de/EN/Research/TransferringResearchIntoPractice/FederalAgencyForDisruptiveInnovation-SPRIN-D/federalagencyfordisruptiveinnovation-sprin-d_node.html.

4 U.S. Department of Defense, *Defense Innovation Unit*, May 2025, https://www.diu.mil/.

General Overview

Out of the 26 nations and regional blocs analyzed in the index, Italy ranks in the 14th position, well below other European peers like the United Kingdom, Germany, France, while being positioned above Spain and the Netherlands.

The positioning within the index is affected by a situation of under-performance in Quantum technologies. Italy stands in the upper part of the ranking in AI and Semiconductors, while occupying a medium position in Space technologies and Biotechnologies.

Artificial Intelligence

Status Quo

Italy is a rapidly growing AI ecosystem, driven by recent EU-wide initiatives. The country excels in AI research, is engaged in key global forums, and has a sophisticated regulatory framework enacted at both national and EU level through the AI Act. Italy ranks amongst the top 7 global countries for Top 500 supercomputers, with facilities like CINECA's Leonardo supercomputer (ranked 4th in Europe and 7th worldwide). However, Italy lags behind in AI commercialization, with venture capital (VC) investments in AI startups reaching only a fraction of those in France and Germany. The country has no major players in foundational machine learning (ML) models like LLMs or vision systems, and Italian AI startups have yet to scale internationally to compete with US, UK, or Chinese firms.

Recommendations

- **Expand existing funding efforts with the PPP model** – Italy should evolve the existing €1 billion CDP-backed fund into a dedicated National AI Growth Fund, structured as a public–private investment vehicle modeled on France's "Tibi[5]" initiative and Germany's Zukunftsfonds.[6] The fund should attract institutional capital through de-risking mechanisms such as first-loss guarantees and tax incentives, with a focus on scale-ups and on developing large-scale foundation models, LLMs or vision models. These models should be built via public-private consortia involving top research institutions e.g., National Research Council of Italy - CNR, Italian Institute of Technology - IIT, access to sovereign computing infrastructure e.g., CINECA's Leonardo supercomputer, and private sector datasets from banking, telecom, manufacturing, and healthcare. Investment should be tied to commercialization outcomes, like patent filings, model performance, and international licensing, and aligned with European instruments such as InvestEU and the European Innovation Council (EIC).
- **Launch a national AI talent development program** – Building on the pilot AI education programs in schools as well as on the National PhD Program[7], Italy should collaborate with schools, universities and companies to integrate AI-related courses at all levels of education and training programs.

5 French Treasury (Direction générale du Trésor), *Financing the Fourth Industrial Revolution*, accessed May 13, 2025, https://www.tresor.economie.gouv.fr/banque-assurance-finance/financing-the-fourth-industrial-revolution.

6 KfW, "KfW supports digitalisation strategy of the Federal Government with new promotional programme," press release, March 12, 2025, https://www.kfw.de/About-KfW/Newsroom/Latest-News/Pressemitteilungen-Details_643072.html.

7 Italian National PhD Program in Artificial Intelligence, *AI & Society*, accessed May 13, 2025, https://www.phd-ai.it/en/359-2/.

Additionally, the government should create a dedicated "Brain Gain" track offering competitive relocation packages, startup capital, and fast-track academic or research appointments to Italian AI researchers abroad. Finally, AI-focused accelerators should be launched in key innovation hubs e.g., Milan, Turin, Rom), offering spin-off support, tech transfer assistance, and international exposure.

- **Boost the investment in new AI infrastructure** – Italy should increase funding to enhance computing infrastructure and data repositories, offering subsidized cloud credits and testing environments to support research institutions and businesses. Investments should be designed to be interoperable with the Common European Data Spaces.[8] To further encourage uptake, the government should introduce AI adoption vouchers and fast-track procurement channels to pilot AI applications in public administration. These platforms should also be eligible to host regulatory sandboxes under the AI Act, where companies can test high-risk systems in a controlled environment.

Biotechnologies

Status Quo

Italy's biotech sector is witnessing a strong development following the Covid-19 pandemic in 2020. The country has world-class human capital, translating into one of the highest global numbers of publications and milestones in the sector, e.g., in genetic engineering, biology, nuclear medicine, genomics, antibiotics, and synthetic biology. Despite its achievements, the country suffers from a low level of innovation in this field. The numbers in research publications do not translate into leadership in new patents. The level of funding, mainly private, remains modest compared to European peers (two times less than France, four times less than Germany). The regulatory environment remains very tight, with Italy banning or mostly prohibiting activities related to human and agricultural gene therapy and editing, as well as GM crops production.

Recommendations

Given the breadth of the sector, the following recommendations should receive priority application in areas where Italy holds a potential strategic advantage and significant potential for economic return, in particular mRNA-Based Therapies and RNA Technologies, Microbiome Engineering and Synthetic Biology, Precision Medicine and Advanced Therapies.

- **Boost government and private funding** – The government should significantly increase public investment to levels comparable with the most advanced European economies (2-3x the current level) and strategically allocate these funds toward matching grants for university spin-offs and early-stage biotech startups. To further stimulate private investment, Italy should attract and facilitate VC funding through a combination of IPO incentives, R&D tax breaks and risk-tolerant co-investment mechanisms, drawing inspiration from the UK's "Patent Box" regime.[9]

- **Launch a large commercialization program** – Italy must convert its strong research output into a higher number of patents by fostering a more effective innovation ecosystem. To achieve this, the government could introduce a performance-based funding mechanism that rewards successful

8 European Commission, *Common European Data Spaces*, accessed May 13, 2025, https://digital-strategy.ec.europa.eu/en/policies/data-spaces.

9 UK Government, *Corporation Tax: The Patent Box*, updated February 1, 2024, https://www.gov.uk/guidance/corporation-tax-the-patent-box.

commercialization outcomes by dedicated universities' technology transfer offices and facilitate licensing agreements or spin-off creation. Additionally, Italy should introduce outcome-based public procurement mechanisms to drive commercialization and implement expedited patent review processes for biotech-related applications, ensuring faster market entry and greater global competitiveness. A dedicated initiative, similar in spirit to the "Montalcini Global Biotech Tour[10]", should incentivize participation in global biotech markets and events.

- **Implement regulatory reforms to boost innovation** – Italy should establish "Innovation Zones", close to high-potential clusters like Bioindustry Park Silvano Fumero in Piedmont for m-RNA therapies and Mirandola Biomedical District in Emilia Romagna for microbiome matters, to enable controlled biotech R&D testing and commercialization, fostering a dynamic environment for scientific advancement. A high-level bipartisan committee should revisit current bans on gene editing and GMOs, balancing ethical considerations with the economic and health benefits of innovation. Fast-track regulatory approval for biotech patents and clinical research as well as centralized competencies - currently split between ministries, agencies, and regions - would reduce administrative bottlenecks and stop the migration of Italian startups to the US.

Financial Technologies

Status Quo

Italy's fintech ecosystem has been gaining momentum over the last decade, but it remains smaller compared to major European fintech hubs such as the UK, Germany, or France. The fintech sector is experiencing a steep growth with over EUR 1B of total funding in 2023.[11] The country consistently ranks in the top positions for high-quality research publications. Italy is deeply involved in the definition of a European CBDC and is part of global agreements for the development of financial technologies. With respect to other peers, the Italian fintech ecosystem lacks a world class cybersecurity framework and suffers from a below-standard internet bandwidth.[12] While under development, the evolution of regulation for crypto-currencies remains limited.[13]

Recommendations

In order to advance its position in the sector, Italy could benefit from the following actions:

- **Strengthen cybersecurity framework** – In line with EU DORA and NIS2 regulation, Italy should reinforce its cybersecurity framework including AI-driven fraud detection and automation measures for continuous monitoring and support fintech firms in applying zero trust architecture, encrypted APIs and strict third-party management.

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10 Italian Trade Agency (ICE), *Evento: Spazio e Innovazione – Prospettive 2025*, accessed May 13, 2025, https://www.ice.it/it/area-clienti/eventi/dettaglio-evento/2025/@@/016.

11 Banca d'Italia, *Indagine Fintech nel Sistema Finanziario Italiano* (Rome: Banca d'Italia, April 2024), https://www.bancaditalia.it/pubblicazioni/indagine-fintech/2023/2023-indagine-fintech.pdf.

12 Orizzonti Politici, "Dalla Copertura alla Velocità: L'Italia e i Divari nelle Telecomunicazioni," accessed May 13, 2025, https://www.orizzontipolitici.it/divari-italia-telecomunicazioni/.

13 Matteo Di Felice, "Fintech: Situazione e Prospettive in Italia e nel Mondo," *StartupItalia*, August 27, 2024, https://startupitalia.eu/smartmoney/fintech-situazione-e-prospettive-in-italia-e-nel-mondo/.

- **Accelerate the development of a comprehensive digital infrastructure** – Italy should accelerate the implementation of the plan "Digital Italy 2026" to ensure a high-speed internet infrastructure in Southern regions and rural areas by, e.g., collaborating with satellite platforms. This would create a higher user base for fintech firms increasing the appeal of the Italian market.
- **Support the creation of national champions and their internationalization** – In order to fill the gap with the UK, France and Germany, Italy needs to reinforce funding mechanisms for late-stage start-ups, enlarge regulatory sandbox applications and support the promotion and export of Italian fintech services to compete with their European peers.

Semiconductors

Status Quo

In recent years, the EU has launched major initiatives to narrow the gap with global leaders like the US and China in the semiconductor industry. Italy ranks second in the EU by number of companies operating in micro-electronics, supported by a combination of foreign investments, joint ventures such as STMicroelectronics, and a robust ecosystem of SMEs spanning the entire value chain, mainly on the front-end side. Italy lacks large national players on below 10-nm fab, fabless, EDA, Assembly, packaging & testing sides.[14]

Italy enjoys a strong research ecosystem but limited new patents productions (approximately 3x less than France and 5x less than Germany). The government has been attempting to revive the industry with a EUR 4B investment in 2022 as part of the EU Recovery Fund and the creation of the Chips.IT Foundation hub at the University of Pavia.[15] It has a dedicated industrial program and is part of the main global institutions and councils for coordination and development e.g., the World Semiconductor Council (WSC) and the Trade and Technology Council (TTC).[16]

Recommendations

In order to advance its position in the sector, Italy could benefit from the following actions:

- **Boost support for scaling of SMEs** – Italy should launch a dedicated co-investment fund - modeled on France's "Electronique 2030[17]" and aligned with the Draghi report's call for pooled EU-scale financing - to support scale-ups of high-potential semiconductor SMEs. This "SME Semiconductor Catalyst Fund" would provide targeted financing to SMEs working in strategic applications such as EVs, renewable energy systems, aerospace, and AI chips. To complement this, Italy should expand existing R&D tax credits for microelectronics and simplify their access, with a special emphasis on

14 AWARE – A World of Awareness, *L'Italia dei semiconduttori: Opportunità strategiche per una filiera europea* (Rome: AWARE Think Tank, June 2023), https://www.awarethinktank.it/wp-content/uploads/2023/06/Giu2023-AWARE-Semiconduttori-Italia.pdf.

15 Italian Trade & Investment Agency (ITA), *Microelectronics and Semiconductors in Italy*, accessed May 13, 2025, https://www.investinitaly.gov.it/en/sectors/microelectronics-semiconductors.

16 Italian Ministry of Economy and Finance (MEF), *Nota Tematica n. 3/2023: Il ruolo della politica industriale nel rilancio degli investimenti pubblici e privati in Italia*, July 2023, https://www.dt.mef.gov.it/export/sites/sitodt/modules/documenti_it/analisi_progammazione/note_tematiche/Nota-Tematica-n-3-2023.pdf.

17 French Ministry for Europe and Foreign Affairs, *France Relance: Recovery Plan – Building the France of 2030*, accessed May 13, 2025, https://www.diplomatie.gouv.fr/en/french-foreign-policy/economic-diplomacy-foreign-trade/promoting-france-s-attractiveness/france-relance-recovery-plan-building-the-france-of-2030/.

early-stage fabless companies, EDA developers, and photonics innovators. Structured public-private consortia should be encouraged, where large national firms like Leonardo, Ferrari, Enel, or TIM commit to co-investment and/or long-term procurement agreements with promising chip SMEs. This would create demand certainty, reduce market risk, and accelerate industrial validation.

- **Promote the development of targeted skills programs and accelerators** – In line with the "Tech Skills Acquisition Programme" proposed by Draghi's report[18], Italy should financially support existing excellence centres like Pavia University, Milan and Turin Politecnico to reinforce targeted scholarships and graduate programs in micro-electronics, providing accelerators and incubators opportunities for high-tech startups. These accelerators, involving European champions like STMicroelectronics, ASML, and Leonardo, should provide access to shared infrastructure, cloud-based design platforms (in line with the EU Chips Act's Design Platform[19]), and structured IP generation fellowships that reward patent development and technology transfer.
- **Localize knowledge by attracting foreign investments** – Italy should build on its recent FDI successes, such as Silicon Box's €3.2 billion packaging facility in Novara[20], by implementing a targeted "Semiconductor Landing Pad" strategy. This initiative would offer tailored incentives e.g. fast-track permitting, tax credits, access to CHIPS.IT and regional hubs to attract fabless design firms, testing and assembly specialists, and EDA tool providers. The goal is to fill gaps in the semiconductor value chain while maximizing knowledge spillovers and strengthening domestic capabilities. To enhance this, the government should actively facilitate strategic partnerships between foreign investors and large national anchor buyers like Leonardo, Enel, and Fincantieri. These firms can provide long-term procurement guarantees and even equity co-investments to de-risk projects.

Space Technologies

Status Quo

Italy has a notable presence in the global space sector. It has been the fifth country in the world to have a machine in orbit (the San Marco I), played a significant role in the development of the International Space Station (ISS) and contributed with several astronauts, amongst them the first woman to lead the ISS, Samantha Cristoforetti. Italy's powerful defense company, Leonardo, also partnered with other European companies like the French Thales to form the largest satellite manufacturer in continental Europe.[21] The country has a strong research and workforce base, with significant academic contributions to space technologies and being very active in contributing to new space missions. Italy is highly engaged in international space cooperation, participating in initiatives such as the Artemis Accords and Combined Space Operations (CSpO). It has also a major role in EU's satellite navigation system Galileo.[22]

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18 Mario Draghi, *The Future of European Competitiveness: A Competitiveness Strategy for Europe*, European Commission, September 9, 2024, https://commission.europa.eu/topics/eu-competitiveness/draghi-report_en.

19 European Commission, *European Chips Act: The Chips for Europe Initiative*, May 2025, https://digital-strategy.ec.europa.eu/en/factpages/european-chips-act-chips-europe-initiative.

20 Reuters, "Silicon Box Picks Italy's Piedmont Region for $3.4 Billion Chip Plant," June 28, 2024, https://www.reuters.com/technology/silicon-box-picks-piedmont-region-its-italian-34-bln-chip-plant-2024-06-28/.

21 Tim Marshall, *The Future of Geography: How Power and Politics in Space Will Change Our World* (London: Elliott & Thompson, 2023).

22 Eleonora Ardemagni, *Italy's Space Strategy: Bridging Autonomy and International Cooperation*, Istituto Affari Internazionali, July 2023, https://www.iai.it/sites/default/files/iai2321_en.pdf.

Italy invests significant economic resources in space, out of them 88% coming from government funding and the rest from private sector funding. The economic involvement of the private sector remains very low if compared with other comparable players like France, Germany, UK whose private sector respectively contributes close or more than 50% of total space funding.[23]

Italy's security capabilities remain modest in terms of military-grade directed-energy weapons and jamming technologies. It lacks a major domestic orbital launch site, which limits its independent access to space and has a relatively small number of communication satellites in orbit.

Recommendations

In order to advance its position in the sector, Italy could benefit from the following actions:

- **Boost the development of defense space startups through cash and non cash incentives** – Italy should adopt a strategy that combines financial incentives with structural reforms to support the growth of space startups. Drawing on successful models from Israel and the US, support for national champions like Leonardo must be paired with targeted measures to help early-stage companies flourish. In the inception phase, the government should simplify bureaucratic procedures and attract specialized venture capital through matching grants. To enable scale-up, awarding stable government contracts can boost startup credibility and facilitate expansion into other European markets. Finally, removing obstacles such as Italy's disproportionately high insurance fee i.e., operators must secure insurance coverage of up to €100 million per incident, significantly higher than in countries like France (€60 million), would reduce operational burdens and allow startups to channel scarce initial capital into high-potential R&D activities.[24]
- **Bolster defense-specific R&D for advanced space security capabilities –** Italy should leverage its long-standing expertise in observation and dual-use systems while intensifying investments in advanced directed-energy and electronic warfare prototypes. This strategy should be seamlessly integrated into the European Defense Strategy and NATO's Defence Innovation Accelerator for the North Atlantic **(**DIANA[25]) initiative. Effective implementation will require close collaboration between large corporations, SMEs and academic institutions to drive innovation and maintain technological leadership in the defense sector.
- **Accelerate the development of IRIS –** Italy needs to play a pivotal role in reinforcing the European alternative to Starlink, IRIS[26], by complementing its security-focused infrastructure with a robust commercial offering, mirroring the approach of the US giant. To achieve this, Italy should actively support Leonardo and smaller industry players in securing a significant share of the satellite manufacturing (currently controlled mainly by France), ground-segment integration, and service provision market. This effort should be backed by procurement incentives and technology transfer programs, fostering innovation, industrial growth, and strategic autonomy within the European space sector.

23 AWARE – A World of Awareness, *L'ecosistema italiano dello spazio* (Rome: AWARE Think Tank, July 2024),https://www.awarethinktank.it/wp-content/uploads/2024/07/LECOSISTEMA-ITALIANO-DELLO-SPAZIO-AWARE.pdf.

24 AWARE – A World of Awareness, *L'ecosistema italiano dello spazio* (Rome: AWARE Think Tank, July 2024), https://www.awarethinktank.it/wp-content/uploads/2024/07/LECOSISTEMA-ITALIANO-DELLO-SPAZIO-AWARE.pdf.

25 NATO Defence Innovation Accelerator for the North Atlantic (DIANA), *Homepage*, accessed May 13, 2025, https://www.diana.nato.int/.

26 European Union Agency for the Space Programme (EUSPA), *IRIS²: Secure Connectivity*, accessed May 13, 2025, https://www.euspa.europa.eu/eu-space-programme/secure-satcom/iris2.

Quantum Technologies

Status Quo

Despite being an emerging player, Italy exhibits promising strengths in quantum technologies. The country boasts a strong academic and scientific ecosystem, with leading research institutions, universities, and national laboratories engaged in all areas: quantum computing (QC), quantum simulation (QS), quantum communication (QComm), and quantum sensing & metrology (QSM). The Italian academic system contributes significantly to European-level projects, aligning with major international initiatives like EuroQCI (Quantum Communication Infrastructure) and EuroHPC-JU (European High-Performance Computing Joint Undertaking). Italy holds recognized expertise in QComm, with startups such as QTI (Quantum Telecommunications Italy) leading in Quantum Key Distribution (QKD) solutions. The Agenzia per la Cybersicurezza Nazionale (ACN) and Istituto Nazionale di Ricerca Metrologica (INRIM) are at the forefront of integrating quantum cryptography into national security frameworks. Italy also excels in QSM, with applications in medical diagnostics, geophysical monitoring, and high-precision navigation. However, Italy suffers from significantly lower funding at both public (12% of French, <8% of German, <6% of UK government funding) and private levels (only 1-2% of respectively French, German, and UK VC investments in 2023). The country lacks dedicated quantum venture capital funds, has no mature domestic QC companies, and remains dependent on foreign quantum semiconductor foundries, posing IP risks. Infrastructure gaps include long wait times for QC access and the absence of a national quantum cloud. Additionally, Italy has no structured national quantum education program, unlike France, Germany, and the UK. Finally, governance is fragmented, lacking a centralized strategy to integrate research, industry, and funding, slowing down technological progress.[27]

Recommendations

- **Strengthen research and infrastructure** – Italy needs to match UK, Germany and France when it comes to public funding efforts. Additional money should be dedicated to develop a national quantum computing cloud, integrating hybrid classical-quantum computing resources and providing on-demand access for universities, startups, and industry. In parallel, government efforts should finance the creation of a quantum innovation hub, with dedicated facilities for hardware development, software stack optimization, and technology transfer, to foster collaboration between academia and private sector players.

- **Promote industry participation and market development** – Italy should support early stage startups through its sovereign wealth fund CDP or a dedicated unit. A targeted tax incentive scheme should be introduced for private R&D investment in quantum computing, communication, and sensing, similar to the UK's R&D tax credits. The government should launch co-investment schemes with corporate players like Leonardo, STMicroelectronics, Eni, Enel, and TIM to de-risk early-stage quantum ventures. Additionally, a public-private accelerator should be established to support spin-offs from research institutions, ensuring Italy builds a robust quantum startup ecosystem.

- **Invest in education and workforce development** – The Ministry of Education should work with universities to design structured master's and PhD programs to build high-skilled human capital, work with large companies and startups to ensure the accumulation of meaningful work experiences,

27 Italian Ministry of University and Research (MUR), *Quantum Information Science: Master Plan for Consultation*, March 2025, https://www.mur.gov.it/sites/default/files/2025-03/QIS_master_for_consultation.pdf.

modeled after Germany's Quantum Flagship Initiative[28], and provide targeted incentives to retain talent, avoiding the brain drain towards other EU countries, and promote the local creation of quantum innovations and commercial applications.

Governance Structure

Italy actively promotes innovation and funds emerging technologies through multiple entities, including ministries, CDP Venture, Fondo Internazionale Innovazione, and PNRR initiatives. However, the country lacks a centralized structure dedicated to long-term experimentation and strategic innovation.

A SPRIND-like Italian agency for high-risk, high-reward innovation would complement existing instruments, providing flexible funding, reduced bureaucratic constraints, and strong academic-industry collaboration. This approach would catalyze disruptive technologies while reinforcing industrial leadership and defense autonomy.

Given that setting up a new governance structure is a lengthy process, the government could take an interim step by strengthening the Deep-Tech division of CDP, while securing the necessary approvals to eventually spin off an independent entity— the Italian Emerging Technology Agency (IETA).

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28 Matt Swayne, "German Flagship Project PlanQK Sets New Course Towards Economic Use for Quantum," *The Quantum Insider*, December 19, 2023, https://thequantuminsider.com/2023/12/19/german-flagship-project-planqk-sets-new-course-towards-economic-use-for-quantum/.

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Critical and Emerging Technologies Index 2025: Japan Report

Executive Summary

Japan ranked fourth overall, led by its strength in semiconductors and biotechnology. However, scores are similar to those of European countries and South Korea, and performance in other technologies remains moderate. To enhance international influence across all technologies, it is essential to translate strong academic research into practical and commercial success. Key priorities include:

1. Strengthening industry-academia-government collaboration (including within government);
2. Expanding domestic demand through cross-sector applications;
3. Promoting international collaboration;
4. Creating an environment for implementing emerging technologies (e.g., digital transformation); and
5. Growing the pool of talent with technical understanding.

Human capital is also vital for sustaining research excellence. Expanding university programs, facilitating international talent exchange, and providing more opportunities to engage directly with emerging technologies would be important.

General Overview

Japan ranks **4th overall**, driven by its strength in **semiconductors**, with strong capabilities across the supply chain—including **materials, equipment, and manufacturing**. Beyond semiconductors, **biotech** also ranks **4th**, supported by high scores in **regulatory**.

In contrast, **quantum** technologies rank **8th**, while **space** ranks **9th,** and **AI** ranks **10th**. To enhance global

influence in these areas, it is important to **strengthen both the development and application foundations**, including **human capital**, **data**, **market**, and **economic resources**.

Artificial Intelligence

Status Quo

- While **economic resources** and **computing power** are relatively competitive compared to higher-ranked countries, **human capital**, **algorithms**, and **data** remain areas of weakness.
- Digital transformation (DX) in businesses has not progressed sufficiently[1], hindering the application of AI-related technologies—for example, paper-based contracts and medical records limit the potential for effective data use.
- The government is supporting the procurement of computing resources and subsidizing usage to improve the AI-development environment. Initiatives to promote the establishment of data centers are also being taken. In terms of AI safety, Japan established AISI, an organization to study methods for ensuring AI safety.[2]

Recommendations

Japan, facing an aging population and labor shortages, has great potential for AI implementation in society. To accelerate DX and expand usable data, policy support for **AI application**—in addition to its development—is essential. Based on insights from industry professionals and expert reports, the following actions are recommended.

- **Development side:** Improve the development environment to promote **industry-specific AI models**, such as in the healthcare and robotics industries. This includes securing computing power and creating appropriate data-sharing frameworks.
- **Application side:** Ensure equitable, nationwide access to computing power. Promote policies that support DX, including financial incentives and training for business leaders to understand its benefits. Accelerate industry digitalization to facilitate AI adoption and **generate more data for AI training**.
- **Human Resources**: Train professionals who can effectively understand and apply AI in practice. To strengthen algorithm development in Japan, it is essential to **attract R&D centers of foreign companies** with cutting-edge AI expertise and **enhance AI-related university programs** to fundamentally build domestic AI development capabilities.

1 Information-technology Promotion Agency (IPA). DX White Paper 2023, Accessed May 8, 2025. https://www.ipa.go.jp/publish/wp-dx/gmcbt8000000botk-att/000108043.pdf.

2 Ministry of Economy, Trade and Industry (METI)." Current Status and Future of Semiconductor and Digital Industry Strategy," December,2024, https://www.meti.go.jp/policy/mono_info_service/joho/conference/semicon_digital/0012/handeji4r.pdf.

Biotechnologies

Status Quo

- Japan has unique regulations in gene therapy, including a fast-tracked approval system designed to deliver medicines as quickly as possible to patients.[3] In other areas, such as agriculture[4], Japan is also considered to have light regulation compared to other global powers.
- Japan has produced Nobel Prize-winning researchers in physiology or medicine and remains academically competitive on a global scale. Despite this, the market share of Japanese pharmaceutical companies is declining.[5] The number of top-selling global drugs developed by Japanese firms continues to fall.[6]
- As major COVID-19 vaccines were based on biopharmaceutical technologies, Japan's inability to produce them domestically and its heavy reliance on imported vaccines highlighted the country's lag in biopharmaceutical development.[7]

Recommendations

Based on insights from expert reports, the following actions are recommended:

- **Strengthen the translation of research into advanced pharmaceuticals** by fostering practical know-how and building a robust drug discovery ecosystem—supporting end-to-end collaboration among academia, startups, pharmaceutical companies, CROs, and CDMOs.[8]
- **Leverage Japan's extensive health and medical data—**an asset of its super-aged society—by developing regulatory and technical infrastructure that enables its secure and effective use for healthcare innovation and **AI-driven drug discovery.**
- **Connect knowledge and technology to commercialization** such as developing venture capital that provides continuous support beyond the middle and later stages. In Japan, investment amounts are smaller compared to the U.S., making it difficult for mid-stage ventures that require significant funding. Moreover, while many crossover funds in the U.S. provide risk capital consistently from pre-IPO to post-IPO stages, such funds are largely absent in Japan.[9] These efforts also include facilitating the

3 Pharmaceuticals and Medical Devices Agency, Efforts for Approval Review and Regulatory Science Promotion of Regenerative Medicine Products, 9th Meeting of the Health and Medical Care Strategy Promotion Headquarters, Prime Minister's Office, June 2023, https://www.kantei.go.jp/jp/singi/kenkouiryou/saisei_saibou_idensi/dai9/siryou2.pdf

4 Genetic Literacy Project, "Japan – Gene Editing in Animals," CRISPR Gene Editing Regulation Tracker, accessed May 7, 2025, https://crispr-gene-editing-regs-tracker.geneticliteracyproject.org/japan-animals/.

5 Eriko Hashimoto, "Japan's Presence in the Pharmaceutical Market," Office of Pharmaceutical Industry Research (OPIR)," November 2019, https://www.jpma.or.jp/opir/news/058/07.html.

6 Hiroyuki Mano, "Current State of Drug Discovery in Japan and the World," presentation at the 1st Meeting of the Conference on Enhancing Drug Discovery Capability, Cabinet Secretariat, Government of Japan, December 27, 2023, https://www.cas.go.jp/jp/seisaku/souyakuryoku/dai1/siryou5.pdf.

7 Ministry of Economy, Trade and Industry. "Reviving the 'Pharmaceutical Powerhouse': Japan's Bio Comeback." METI Journal, November 28, 2022. https://journal.meti.go.jp/p/24338/.

8 Ministry of Economy, Trade and Industry, "The Current State and Future Direction of Bio Policy", February 22, 2024, https://www.meti.go.jp/shingikai/sankoshin/shomu_ryutsu/bio/pdf/018_04_00.pdf.

9 Nagayoshi, Ryozo. Challenges in Biopharmaceutical Drug Discovery and Development. Presentation at the 22nd Meeting of the Health and Medical Care Strategy Promotion Headquarters, Prime Minister's Office (Japan), June 2023. https://www.kantei.go.jp/jp/singi/kenkouiryou/sanyokaigou/dai22/siryou2-5.pdf.

matching of managerial talent and leadership.

Semiconductors

Status Quo

- Japan is positioned highly across a wide range of areas including **manufacturing**, **raw materials and wafers**, and **equipment**.
- The main differences between Japan and the top-ranked countries (the **United States** and **China**) lie in **human capital** and **chip design and design tools**, suggesting that Japan has relative weaknesses in the **software-related aspects of semiconductors**.
- Even within manufacturing, while **KIOXIA** continues to produce cutting-edge **NAND memory**, Japan relies heavily on imports for advanced **logic semiconductors**.[10]
- In response to these challenges, the Japanese government has introduced the **Japanese CHIPS Act**, supporting **TSMC's investment in Kumamoto Prefecture.**[11]
- They also support **Rapidus**, a startup aiming the **mass production of 2nm semiconductors by 2027.** Rapidus is partnering with **IBM**[12] and is collaborating with international institutions such as **imec**[13]. The company announced that it completed the installation of necessary semiconductor manufacturing equipment for pilot operations by the end of FY2024.[14]

Recommendations

Based on insights from industry professionals and expert reports, the following actions are recommended.

- **Human Capital Development**: Develop outreach strategies and training programs to attract high-skilled young talent. Identify the skills and workforce needed across the broad semiconductor supply chain—from materials to chip design and manufacturing—and build strategic programs to ensure domestic talent development. For areas of weakness, particularly in **chip design**, consider both **bringing in international experts** and **sending domestic talent abroad for training**.
- **Demand Creation**: To sustain the significant and ongoing capital investments required, it is essential to generate sufficient profits and attract private investment. This includes stimulating demand for advanced semiconductors by supporting **AI and other emerging tech application development** and **startups**.

10 Ministry of Economy, Trade and Industry (METI), "Semiconductor and Digital Industry Strategy," June 2023, https://www.meti.go.jp/policy/mono_info_service/joho/conference/semiconductors_and_digital.pdf.

11 Ministry of Economy, Trade and Industry,Certified Specific Semiconductor Production Facility Equipment Plan., accessed May 8, 2025, https://www.meti.go.jp/policy/mono_info_service/joho/laws/semiconductor/semiconductor_plan.html.

12 Rapidus Corporation, "IBM and Rapidus Form Strategic Partnership to Build Advanced Semiconductor Technology and Ecosystem in Japan," December 13, 2022, https://www.rapidus.inc/en/news_topics/information/ibm-and-rapidus-form-strategic-partnership-to-build-advanced-semiconductor-technology-and-ecosystem-in-japan/.

13 Rapidus Corporation, "Rapidus Joins imec's Core Partner Program," April 4, 2023, https://www.rapidus.inc/en/news_topics/information/rapidus-joins-imecs-core-partner-program/.

14 Rapidus Corporation, "NEDO Approves Rapidus' FY2025 Plan and Budget for 2nm Semiconductor Projects," April 1, 2025, https://www.rapidus.inc/en/news_topics/information/nedo-fy2025-approval/.

Space Technologies

Status quo

- Japan demonstrates **relative strength in human resources** compared to countries like the **UK, France, and India**, which have higher overall scores and show particular strength in **remote sensing**. Japan also has a strong **international reputation** through the **Japan Aerospace Exploration Agency (JAXA)**. However, while China and the US have increased their rocket launch successes by five and eight times over the past decade, Japan has seen little change, indicating limited market and demand growth.[15]

- Private investment remains low, highlighting a weakness in economic resources. 1) Limited private sector activity, [16] 2) the industry being led by large conglomerates[17] that find it difficult to focus solely on a specific sector, and 3) Small number of investors[18] may be potential reasons. Amid these circumstances, some startups have succeeded to scale up (e.g, Astroscale has succeeded in becoming a global leader in on-orbit debris removal services).

- The government has established a **Space Strategy Fund** in JAXA in 2024 (Target: ¥1 trillion support over 10 years[19]) to support private companies in embarking on business in the space area.

Recommendations

To draw in more private investment, expanding the market is essential. Based on insights from industry professionals and expert reports, the following actions are recommended:

- **Utilization of anchor tenancy**: The government leads the industry by setting direction and attracting private customers, especially until the space industry becomes self-sustaining.[20]

- **Expansion into the global market**: The Japanese market lacks sufficient demand to scale the industry. To address this, it is essential to expand into global markets by building regional partnerships across the Asia-Pacific and sharing societal challenges and needs.[21]

- **Grow the customer base**: Expand into areas such as space-based drug and material production, and space station maintenance. Use Japan's strength in robotics to stand out from other countries.[22]

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15 Ministry of Economy, Trade and Industry, Direction for Strengthening the Space Industry Foundation,March 2025, https://www.meti.go.jp/shingikai/sankoshin/seizo_sangyo/space_industry/pdf/004_06_00.pdf.

16 Ministry of Finance (Japan), Monthly Report on Public Finance Statistics: Toward the Development of Japan's Space Industry, August 2022, https://www.mof.go.jp/public_relations/finance/202208/202208h.pdf.

17 Ministry of Economy, Trade and Industry,Trade and Industry, METI's Past and Future Efforts on Domestic and International Trends in the Space Industry,March 2024,https://www.meti.go.jp/shingikai/sankoshin/seizo_sangyo/space_industry/pdf/001_05_00.pdf

18 Ministry of Finance (Japan), Monthly Report on Public Finance Statistics: Toward the Development of Japan's Space Industry, August 2022, https://www.mof.go.jp/public_relations/finance/202208/202208h.pdf.

19 Government of Japan (Cabinet Office et al.), Space Strategy Fund Basic Policy, April 26, 2024, https://www.meti.go.jp/press/2024/04/20240426002/20240426002-1.pdf.

20 Hideyuki Aoki, "Toward an Era Where Everyone Can Enjoy Space Travel,"Grasp, Ministry of Land, Infrastructure, Transport and Tourism (Japan), September 29, 2020, https://www.magazine.mlit.go.jp/interview/vol21-c-2/.

21 Hazuki Mori and Soichi Noguchi, "How Japan Can Remain a Major Player in the Space Sector,", World Economic Forum, December 20, 2024, https://jp.weforum.org/stories/2024/12/how-japan-can-remain-a-star-player-in-the-space-sector-9c343b7fa8

22 Hazuki Mori and Soichi Noguchi, "How Japan Can Remain a Major Player in the Space Sector,", World Economic Forum, December 20, 2024, https://jp.weforum.org/stories/2024/12/how-japan-can-remain-a-star-player-in-the-space-sector-9c343b7fa8

Quantum Technologies

Status Quo

- Compared to leading countries, Japan has relative strength in quantum computing, but weaknesses in quantum sensing, quantum communication, and economic resources.
- Some startups (ex. OptQC-optical quantum computer[23]) and RIKEN (a National Research and Development Agency and the only comprehensive research institution of natural science in Japan[24]), and Fujitsu have developed a domestic quantum computer (superconducting quantum computer).[25] Japan has strengths in materials and component technologies needed for quantum technology. Japan leads in patents granted across quantum technologies with the U.S, but universities offering quantum technology research programs and master's degrees are smaller than the US and EU.[26]
- To promote the creation of new industries through quantum technologies, Q-STAR—a consortium of industries—has been established.[27] Additionally, a research center (G-QuAT) that provides private-sector access to quantum computers to accelerate the application of quantum computing was established by the National Institute of Advanced Industrial Science and Technology.[28]

Recommendations

Based on insights from industry professionals and expert reports, the following actions are recommended.

- **Human Resource Development**: Expand the pipeline of "quantum-ready" talent (e.g. engineers and generalists from other fields who understand quantum technologies) in addition to quantum specialists.[29] Support this through enhanced university programs.
- **Collaboration Across Sectors:** Strengthen cooperation among government, research institutions, industry, and universities to align academic research with social and industrial needs.[30] Promote inter-ministerial coordination to advance quantum technology in a balanced and unified manner.
- **Attract Global R&D and Talent Exchange**: Encourage the establishment of R&D centers by Global

23 OptQC Corp. OptQC Official Website. Accessed May 8, 2025. https://www.optqc.com/.

24 RIKEN, About RIKEN, accessed May 7, 2025, https://www.riken.jp/about/.

25 Fujitsu Limited and RIKEN. "Fujitsu and RIKEN Develop Superconducting Quantum Computer at the RIKEN RQC-Fujitsu Collaboration Center, Paving the Way for Platform for Hybrid Quantum Computing." October 5, 2023. https://www.fujitsu.com/global/about/resources/news/press-releases/2023/1005-01.html.

26 McKinsey & Company, Quantum Technology Monitor: Steady Progress in Approaching the Quantum Advantage, April 2024, https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/steady%20progress%20in%20approaching%20the%20quantum%20advantage/quantum-technology-monitor-april-2024.pdf.

27 Quantum Strategic Industry Alliance for Revolution (Q-STAR). Q-STAR Official Website. Accessed May 8, 2025. https://qstar.jp/en.

28 National Institute of Advanced Industrial Science and Technology (AIST). Global Research and Development Center for Business by Quantum-AI Technology (G-QuAT). Accessed May 8, 2025. https://unit.aist.go.jp/g-quat/index_en.html.

aist.go.jp

29 Heewon Choi (CEO, JellyWare Inc.), Proposal on Quantum Talent Development and Business Creation from the Perspective of Business Challenges, Working Group on Quantum Technology Implementation, Cabinet Office, Government of Japan, 8th Meeting, February 20, 2023, https://www8.cao.go.jp/cstp/ryoshigijutsu/jitsuyo_wg/8kai/siryo2-1.pdf.

30 Ministry of Economy, Trade and Industry (Japan), "The Path to Industrialization of Quantum Technology: Let's Have Various Companies Speak Up," METI Journal ONLINE, June 16, 2022, https://journal.meti.go.jp/p/21998/

companies in Japan and promote international talent exchange[31], ensuring Japan's quantum industry has access to cutting-edge global technologies. Engage materials industries from the early stages to maintain Japan's strengths in quantum computing.

Governance Structure

- The Council for Science, Technology and Innovation (CSTI), chaired by the Prime Minister and composed of relevant Cabinet ministers (such as MEXT[32], METI[33], and MOF[34], along with experts, oversees Japan's national science and technology policy.[35] For key national priorities, such as space[36], a dedicated Headquarters is established within the Cabinet, also chaired by the Prime Minister and composed of relevant ministers.
- At the ministerial level, for example, MEXT leads research and development in advanced and critical science and technology fields (e.g., space), and promotes creative and basic research. METI oversees R&D and the promotion of industrial technologies, as well as the creation of new industries and improvement of the business environment.[37]
- Under these ministries, research is carried out by national universities and Independent Administrative Agencies such as the JAXA, JST, and the New Energy and Industrial Technology Development Organization (NEDO). Some of these agencies—such as JST and NEDO—also serve as funding organizations. The roles and areas of focus of each agency are defined by law and differ accordingly.[38]

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31 Taro Shimada, "Challenges for Creating New Industries through Quantum Technology," presentation at the 13th Meeting of the Quantum Technology Innovation Council, Cabinet Office, Government of Japan, January 26, 2023, https://www8.cao.go.jp/cstp/ryoshigijutsu/13kai/siryo1-2.pdf.

32 Ministry of Education, Culture, Sports, Science and Technology

33 Ministry of Economy, Trade and Industry

34 Ministry of Finance

35 Council for Science, Technology and Innovation (CSTI), Cabinet Office, Government of Japan. "About CSTI." Accessed May 8, 2025. https://www8.cao.go.jp/cstp/english/policy/index.html.

36 National Space Policy Secretariat, Cabinet Office, Government of Japan. "Space Policy." Accessed May 8, 2025. https://www8.cao.go.jp/space/english/index-e.html.

37 Center for Research and Development Strategy (CRDS), Japan Science and Technology Agency (JST). "Overview Report on Research and Development: System and Information Science and Technology Field (2021)". Accessed May 8, 2025. https://www.jst.go.jp/crds/pdf/2020/FR/CRDS-FY2020-FR-05/CRDS-FY2020-FR-05_10100.pdf

38 Center for Research and Development Strategy (CRDS), Japan Science and Technology Agency (JST). "Overview Report on Research and Development: System and Information Science and Technology Field (2021)". Accessed May 8, 2025. https://www.jst.go.jp/crds/pdf/2020/FR/CRDS-FY2020-FR-05/CRDS-FY2020-FR-05_10100.pdf

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Critical and Emerging Technologies Index 2025: South Korea Report

Executive Summary

South Korea is solidifying its position as a key global player in emerging technologies, with its **overall standing of 5th** in these emerging technologies surpassing its 2023 GDP ranking of 14th globally.[1] This achievement is driven by cutting-edge ICT infrastructure, world-class internet speeds, the government's digital transformation efforts, leading tech companies, and a tech-savvy population.[2]

All five sectors were designated among South Korea's 12 national strategic technologies in 2022. This was followed by the enactment of the Special Act on Fostering National Strategic Technologies in 2023 and the development of a cross-ministerial Basic Plan in 2024. Under the First Basic Plan (2024-2028), the government allocated KRW 6.8 trillion (approximately USD 4.9 billion) in 2025 for targeted R&D across the 12 strategic technologies, with a strong emphasis on AI, semicon, biotech, and quantum technologies.

However, key challenges remain. To stay competitive in an increasingly global landscape, **policy and public funding support** must be both sustained and strengthened. **Talent shortages**–exacerbated by a shrinking population and the growing tendency of STEM students to pursue careers in medicine–are especially acute in semiconductor, AI, biotech, and quantum technologies. The government must remain vigilant in advancing **regulatory reform**, given that global competitors are rapidly easing regulatory constraints. The space sector requires further commercialization. Targeted government support is essential to help companies scale globally and to foster international partnerships, especially in AI and biotech.

1 World Bank, "GDP Ranking," World Bank Group Data Catalog, Dec 18, 2024, https://datacatalog.worldbank.org/search/dataset/0038130.

2 International Trade Administration, "Korea - Digital Economy," Country Commercial Guide, September 19, 2024, https://www.trade.gov/country-commercial-guides/korea-digital-economy.

General Overview

As of 2023, South Korea ranks **5th overall**, with its strongest performance in **semiconductors (5th)**, followed by high rankings in **AI (9th), quantum technologies (12th),** and **biotech (10th)**, while its ranking in **space technologies (13th)** remains relatively low.

The following section examines how the Korean government is strategically fostering the development of these technologies and how Korean companies are adapting to the evolving environment, while addressing the distinct challenges within each sector. Although the data focuses on developments only through 2023, the following section includes more recent updates.

Artificial Intelligence

Status Quo

South Korea has achieved **one of the fastest advancements in AI technology** among major countries from 2018 to 2022.[3] Korea's competitiveness in digital technologies, combined with widespread recognition of AI's importance across government and major companies, strong ICT infrastructure, and an AI-friendly user base, has laid a solid foundation for the growth of its AI ecosystem.

In a recent survey, 55% of Korean respondents reported having used an AI application in the past twelve months, surpassing the global average of 48% (U.S. 29%, Japan 28%, Italy 43%, UAE 71%).[4] Revenues of promising AI application companies have been on the rise. Several sectors have shown particularly strong growth in 2023 compared to 2022, including healthcare (+55.9%), content and education (+33.3%), and mobility and transportation (+25.9%).[5]

In 2024, Korea enacted a **framework act on AI** as the world's second country after the EU, by passing the "Framework Act on the Advancement of Artificial Intelligence and the Establishment of a Foundation for Trust." The government will invest KRW 1.5 trillion (USD 1 billion) in supporting the AI industry in 2025, including the establishment of an AI computing center and the development of artificial general intelligence (AGI).[6]

However, low and declining levels of private investment[7], technology gaps in generative AI, relatively small domestic market, and a limited AI workforce remain key challenges.

3 Institute of Information and Communications Technology Planning and Evaluation (IITP), "2022 ICT Technology Level Survey and Technology Competitiveness Analysis Report," IITP, March 4, 2024, https://iitp.kr/kr/1/knowledge/openReference/view.it?ArticleIdx=6779&count=true&page=1.

4 Ipsos, "Google / Ipsos Multi-Country AI Survey 2024," Google / Ipsos, January 2025, https://www.ipsos.com/sites/default/files/ct/news/documents/2025-01/Google%20Ipsos%20Multi%20Country%20AI%20Study%20Topline%20for%202025%20.pdf.

5 Hyun-jin Lee, "2024 Annual Report on Global Trends in Artificial Intelligence," Korea Development Institute (KDI), May 2025. https://eiec.kdi.re.kr/policy/domesticView.do?ac=0000190894.

6 Sung-hyun Kim, "AI Policy Shaken by President Yoon's Impeachment; Tech Industry Shifts Focus to Presidential Candidates," *Aju Business Daily*, April 6, 2025, https://www.ajunews.com/view/20250406152218091.

7 Seungjoo Lee, "Even in Spring, Startups Remain in a Slump—Number of Investments Drops 24% in Q1," *Newsis*, April 4, 2025, https://www.newsis.com/view/NISX20250403_0003126030. Joe White and Serena Cesareo, "The Global AI Index", *Tortoise Media*, September 19, 2024, https://www.tortoisemedia.com/data/global-ai#rankings.

Recommendations

- **Continue investing in and providing policy support for the establishment of the National AI Computing Center** by 2030. This center is crucial in expanding access to GPU resources. Ensure strategic allocation of GPUs while maintaining accessibility for startups and SMEs.
- **Expand tax incentives to encourage private investment and improve access to data**, especially in light of the low and declining levels of private investment. In particular, strengthen support for generative AI development and prioritize assistance for startups and SMEs.
- To address the significant talent gap which reached 7,841 in 2022[8] and the overwhelming national preference for medical careers, **reform middle and high school education to strengthen AI learning from an early age**. Establish AI-focused academic tracks within STEM-specialized high schools that offer pathways to top universities and major companies.

Biotechnologies

Status Quo

South Korea has made **continuous and remarkable progress** in biotechnology, driven by **sustained public sector R&D investment and private sector-led innovation.**[9] Recognizing biotechnology as a key future growth engine, the government aims to position Korea among the world's top five advanced biotech nations in 2035. In 2022, advanced biotechnology was designated as one of three game-changing sectors, alongside AI·semiconductors and quantum technologies among 12 national strategic technologies. Reflecting this priority, R&D investment in advanced biotechnology reached KRW 2.12 trillion (USD 1.5 billion) in 2025, representing a 19.1% increase from 2024.[10]

To strengthen governance across ministries responsible for science, health, and industry and to enhance public-private coordination, **the National Bio Committee** was launched in January 2025 as a presidential advisory body. The committee brings together relevant ministers, representatives from major biotech firms, and experts from academia and research institutes. Its main proposals include accelerating new drug development, creating mega funds, expanding production capacity, and cultivating professionals. Recent government initiatives also aim to strengthen collaboration among bioclusters, improve data connectivity within the national bio-data platform, and regularly ease regulatory burdens.

Meanwhile, leading biotech firms such as Samsung Biologics and Celltrion are at the forefront of the innovation. These firms possess core technologies and are advancing biotech frontiers by expanding biopharmaceutical manufacturing capacity and developing biosimilars.

8 KIAT, "KiAT's Top 10 Promising Industries for 2024," KIAT, April 17, 2024, https://www.kiat.or.kr/front/board/boardContentsView.do?board_id=71&contents_id=de1bcb256cc54433bf221a10a8ec1a88&MenuId=878cb9b6d5ec41bf914ad5c0f590ed14.

9 Korea Trade-Investment Promotion Agency (KOTRA), "Korea's Biotech Industry, Emerging as a Global Manufacturing Hub of Cutting-Edge Biotechnology," Invest Korea, June 2, 2023, https://www.investkorea.org/ik-en/bbs/i-308/detail.do?ntt_sn=490784.

10 Presidential Advisory Council on Science and Technology, "2026 National R&D Investment Direction and Criteria (Draft)," Presidential Advisory Council on Science and Technology, March 13, 2025, https://www.pacst.go.kr/jsp/council/councilArchiveView.jsp?archive_id=1189.

Recommendations

- To address the fragmented nature of the current biotech landscape and strengthen the R&D ecosystem, **accelerate the development of a comprehensive national bio-data platform** that integrates data from the government, the industry, hospitals, and research centers. This platform should encompass both traditional and advanced biotechnologies to foster innovation and collaboration.
- **Review and reform existing regulatory barriers, and expand public R&D** to accelerate the development and deployment of new drugs while easing burdens on biotech firms. Assess the current national regulations in comparison with international standards and the standards of leading nations.
- Given the modest 7.9% increase in graduate-level human resources in the sector from 2021 to 2022[11], **actively develop the workforce through funding** relevant programs at universities and research centers and establishing partnership programs that bridge academia and industry, both domestically and internationally–including with leading foreign research institutes.

Semiconductors

Status Quo

South Korea possesses a significant position globally, with **major companies** like Samsung Electronics and SK Hynix leading in the production of DRAM and High Bandwidth Memory (HBM) chips. Beyond memory production, South Korea is among the few nations with a **comprehensive semiconductor value chain**, encompassing both DRAM manufacturing and foundry services. particularly in the memory semiconductor sector.

In 2023, Korea maintained its position as **the world's second-largest semiconductor producer** for the 11th consecutive year since 2013. Semiconductors remain one of Korea's leading export items, accounting for 15.6% of total exports in 2023. As a core pillar of the national economy and industry, the sector continues to drive Korea's technological and economic growth.[12]

However, Korea is now at a critical juncture, facing a technology gap amid **intensified global competition**–particularly due to significant governmental support and technological advancements of competitors, as well as trade barriers. Korea is also experiencing a decline in its system semiconductor market share, which stood at 3.1% in 2022[13], and suffering from a shortage of skilled personnels.

The government plans to invest approximately $6.3 billion in the semiconductor industry by 2025 to enhance the competitiveness of the entire industry ecosystem[14]. In February 2025, The National Assembly passed the so-called "K-Chips Act", expanding tax incentives for semiconductor companies.[15]

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11 Korea Institute for Advancement of Technology (KIAT), "2023 Analysis of the Supply and Demand of Industrial Technology Workforce," KIAT, https://www.kiat.or.kr/front/board/boardContentsView.do?contents_id=62f25db0e9fe43a9bae6dcccf313ac79&MenuId=5da1bd8b37ab46788b11421041dd8c74.

12 KOTRA, "Semiconductors," Invest Korea, Accessed April 14, 2025, https://www.investkorea.org/ik-en/bbs/i-308/detail.do?ntt_sn=490784.

13 KIAT, "2024 Industrial Technology Environment Outlook Report," KIAT, April 12, 2024, https://www.kiat.or.kr/front/board/boardContentsView.do?board_id=71&contents_id=8106438a71054885be7ace23db10e3ee&MenuId=878cb9b6d5ec41bf914ad5c0f590ed14.

14 Korea Policy Briefing, "Government to Invest KRW 8.8 Trillion to Be Invested In Semiconductor Industry by Next Year to Strengthen Ecosystem Competitiveness," Policy News, October 16, 2024, https://www.korea.kr/news/policyNewsView.do?newsId=148935134#policyNews.

15 Eun-jin Kim, "K-Chips Act Clears Major Legislative Hurdle, Enhancing Tax Incentives for Semiconductor Industry," *Business Korea,* February 18, 2025, https://www.businesskorea.co.kr/news/articleView.html?idxno=235649.

Recommendations

- **To accelerate the development of semiconductor clusters, the government should increase subsidies, as its competitors have done, and streamline regulations.** A stable manufacturing infrastructure will help the industry to secure investment more easily and build a stronger ecosystem.
- **Further strengthen R&D investment for startups developing AI semiconductors,** a field where South Korea remains comparatively underrepresented. In light of a recent case in which a Korean AI chip startup declined an acquisition offer from META, the government should foster an environment that supports and incentivizes innovation in the non-memory sector.
- **Develop and implement a comprehensive talent development and attraction strategy** to address the talent shortage, which reached 1,752 in 2021.[16] Support national champion companies in delivering relevant curricula at universities, and enhance incentives for foreign R&D professionals to work in and relocate to South Korea.

Space Technologies

Status Quo

South Korea has made remarkable progress in recent decades, marked by its **domestically developed three-stage launch vehicle** Nuri, also known as the Korea Space Launch Vehicle II (KSLV-II), which is capable of placing a 1.5-ton satellite into a 600 to 800 km solar synchronous orbit. It became the seventh country that can launch satellites into high orbits[17] and is now developing the larger KSLV-III. These achievements have been made possible through close collaboration with the nation's leading space companies, including Hanwha Aerospace and Korea Aerospace Industries (KAI). South Korea aims to send a spacecraft to the moon by 2032 and explore Mars by 2045. However, these advancements may not be fully reflected in this ranking, as the broad 'launch' indicator may overlook key differences in national capabilities.

The recent establishment of **Korea Aerospace Administration (KASA)** in 2024 underscores South Korea's ambition to accelerate space exploration and boost its space economy. KASA announced plans to invest KRW 806 billion (USD 580 million) in R&D in 2025–a more than 43% increase from 2024.[18] It is also allocating KRW 380 billion (USD 273 million) between 2024 and 2030 to develop three space industry clusters.[19]

Investment in military space projects has also surged in recent years, a development that may not be fully reflected in this report's data. Since 2023, the military has been implementing Project 425, with KRW 1.3 trillion (USD 936 million)[20] committed through 2025 to acquire five high-resolution military reconnaissance satellites to address North Korea's threats.

16 KIAT, "2024 Industrial Technology Environment Outlook Report," KIAT, April 12, 2024, https://www.kiat.or.kr/front/board/boardContentsView.do?board_id=71&contents_id=8106438a71054885be7ace23db10e3ee&MenuId=878cb9b6d5ec41bf914ad5c0f590ed14.

17 Robert S. Wilson and Nicholas J.Wood, "Country Brief - South Korea," Center for Space Policy and Strategy, August 2023, https://csps.aerospace.org/sites/default/files/2023-08/Wilson-Wood_SouthKorea_20230802.pdf.

18 Korea AeroSpace Administration (KASA), "Korea to Invest KRW 806.4 Billion in 2025 R&D Projects to Become a Top 5 Aerospace Power," press release, March 25, 2025, https://www.kasa.go.kr/prog/bbsArticle/BBSMSTR_000000000041/view.do?bbsId=BBSMSTR_000000000041&nttId=B0000000001475Sj3oS1.

19 KASA, "KASA Announces the 'Space Industry Cluster Tripartite System Construction Project (R&D),'" press release, September 11, 2024, https://www.kasa.go.kr/prog/bbsArticle/BBSMSTR_000000000041/view.do?bbsId=BBSMSTR_000000000041&nttId=B0000000000759Uq5vX6.

20 Jong-Yoon Lee, Jong-Yoon Lee, "South Korea Launches Its 3rd Reconnaissance Satellite to Monitor North Korea," *Financial News*, December 21, 2024, https://www.fnnews.com/news/202412201534445530.

Recommendations

- **Sustain long-term growth in government space R&D while diversifying the budget allocations**, which are currently heavily concentrated on reconnaissance satellites and launch vehicle development. As a second mover, Korea must heavily invest in flagship programs while broadening its spending to manage risks and stimulate the broader space industry.
- **Build a space industry ecosystem rooted in specialized clusters, with targeted financial support for both established firms and startups, and enabling policies to drive the commercialization of space technologies**. Encourage the regulated spin-off of space assets and technologies to maximize their economic impact.
- **Strengthen support for KASA, including increased and sustained funding**. Building on bipartisan support, the government should continue to reinforce KASA's institutional capacity, ensure a consistent upward trend in its funding, and empower the agency to serve as a control tower for the nation's space programs.
- **Continue actively engaging in international partnerships** and build upon its coalition with like-minded countries to uphold the safe and sustainable use of outer space.

Quantum Technologies

Status Quo

Korea is an emerging player with strong potential in quantum technologies. Quantum technologies were designated as one of three game-changing sectors among 12 national strategic technologies, along with AI·semiconductors, and biotechnology.

Major conglomerates, including Samsung Electronics and Hyundai, have been investing in quantum R&D and applications, signaling growing rising interest from the private sector and recognizing quantum as a multiplier in the broader ICT landscape.

Although Korea was relatively late in adopting a comprehensive quantum development strategy, the government has taken **active steps** since launching the Quantum R&D Investment Strategy in 2021[21] and implementing the "Quantum Science and Industry Promotion Act" in 2024. To oversee and coordinate national quantum strategies and initiatives, the Quantum Strategy Council was established in 2025 under the Prime Minister's Office. R&D investment in quantum technologies reached KRW 200 billion (USD 144 million) in 2025, marking an increase of over 50% in 2025 compared to 2024.[22] While the number of essential human resources across industry, academia, and research grew by 29.9% during the same period, it remained limited, totaling just 499 in 2023.[23]

21 Korea Institute of Science and Technology (KIST), "Strategic Directions for AI Development," *KIST Opinion*, August 2023, https://www.kist.re.kr/ko/news/kist-opinion.do?mode=view&articleNo=13066.

22 Hyung-jun Kim, "Quantum Technology Spotlighted by the Drama 'The Three-Body Problem'... A New Growth Engine for Semiconductor Powerhouse South Korea," Korea Institute of Science and Technology (KIST), https://www.pacst.go.kr/jsp/council/councilArchiveView.jsp?archive_id=1189&

23 Ministry of Science and ICT, "MSIT Unveils First Master Plan for Developing Critical and Emerging Technologies (2024-2028): A Blueprint for National S&T Sovereignty," press release, August 26, 2024, https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&bbsSeqNo=42&nttSeqNo=1034.

Recommendations

- **Accelerate the development of quantum clusters**. Drawing from the precedents set by bio clusters, concentrate efforts on a select few rather than dispersing resources. **Strengthen collaborative ecosystems among industry, academia, and research institutes** within these clusters.
- **Maintain increased R&D investment in key quantum technologies** including quantum computing, communications and sensing, where South Korea faces a technology gap compared to leading nations.
- **Expand academic exchange programs with universities in leading nations** in quantum technologies. **Increase public funding and support mechanisms to attract top foreign quantum researchers** to conduct research in Korea.

Governance Structure

The Presidential Advisory Council on Science and Technology (PACST), established in 1989, set Korea's mid- to long-term policy directions for science and technology, including in emerging fields. Chaired by the President and composed of the relevant ministers and civilian experts, the Council designated 12 critical emerging technologies and 50 specific priority technologies in 2022. It also plays a key role in coordinating the government's annual cross-ministerial R&D budgets.

"The Special Act on National Strategic Technologies", enacted in 2023, provides the legal foundation for policies supporting national strategic technologies. Based on this act, the government establishes a five-year Basic Plan.

The Ministry of Science and ICT (MSIT) operates the **Science, Technology, and Innovation Office (STI Office)**, which supports MSIT's coordination role across the government. The STI Office coordinates budgets, and oversees the monitoring and evaluation of policy implementation. Relevant ministries submit their annual and mid-term R&D action plans to the STI Office for review.[24]

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She is a Korean diplomat with six years of experience, specializing in technology and space security diplomacy. At the Disarmament and Non-proliferation Division of the Korean Ministry of Foreign Ministry, she contributed to Korea's space security policy and international cooperation efforts. She also played a key role in organizing the 21st ROK-UN Joint Conference on Disarmament and Non-Proliferation Issues in 2022, which focused on space security.

During her posting at the Korean Embassy in France, she led Korea-France cooperation on United Nations

24 OECD, "Challenges and Opportunities of Mission-Oriented Innovation Policy in Korea," *OECD Science, Technology and Industry Policy Papers*, OECD Publishing, Paris, March 3, 2025, https://www.oecd.org/en/publications/challenges-and-opportunities-of-mission-oriented-innovation-policy-in-korea_d725304c-en.html.

issues and directed Korea's public diplomacy initiatives in the region. Her career also encompasses roles in the Ministry's Human Rights Division, Spokesperson's Office, and Protocol Office.

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