HARVARD Kennedy School
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for Science and International Affairs

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]

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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