



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 **3rd**, 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 sufficiently¹, 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 agriculture⁴, 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/kenkouiryousaisei_saibou_idensi/dai9/siryousiryou2.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/siryousiryou5.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, Ryo. 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/kenkouiryous/sanyokaigou/dai22/siryousiryou2-5.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 conglomerates¹⁷ that find it difficult to focus solely on a specific sector, and 3) Small number of investors¹⁸ 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 years¹⁹) 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

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 computer²³) and RIKEN (a National Research and Development Agency and the only comprehensive research institution of natural science in Japan²⁴), 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/siryos2-1.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 exchange³¹, 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 MEXT³², METI³³, and MOF³⁴, along with experts, oversees Japan's national science and technology policy.³⁵ For key national priorities, such as space³⁶, 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/siryot-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