

EMERGING TECHNOLOGIES AND ECONOMIC RESILIENCE: JAPAN'S PATH FORWARD

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Foreword

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In 1987, I arrived in Japan during the height of its bubble economy as a young computer science student, part of a university study trip. Tokyo's streets were lively, and corporations like Matsushita, Canon, Toshiba, and Fujitsu warmly welcomed us. We were introduced to cutting-edge technologies like the fax machine and ISDN communication lines. The government's "Fifth Generation Computing Project," aimed at advancing Japan's computer architecture and software, exemplified Japan's post-war industrial success fueled by government-led innovation. This formula, combined with visionary leadership from figures like Konosuke Matsushita and Akio Morita, propelled Japan into economic prominence.

Returning to Japan in 1990 as a researcher at Hitachi's Central Research Laboratory, I observed the inner workings of Japan's economic engine. But as the bubble burst, Japan entered its "lost decades." Stock markets collapsed, government initiatives dwindled, and risk-taking founders were replaced by conservative leaders who cut R&D budgets. Global innovation accelerated with the rise of the internet, yet Japan's large corporations were outpaced by agile startups from the U.S., which captured lead positions in software, mobile technology, and semiconductor manufacturing. Japan's firms, now constrained by cautious leadership and dwindling government support, struggled to adapt to the pace of innovation set by global counterparts.

As R&D shifted toward incremental improvements, I transitioned to finance, where new technologies like telephone banking, the internet, and AI transformed the sector. However, Japan's digital adoption lagged, creating inefficiencies that surfaced, especially during the COVID-19 pandemic. Yet today, there's a resurgence of optimism, fueled by the Japanese government's commitment to fostering 100,000 startups and creating 100 unicorns—a shift focused on driving innovation through startups rather than traditional conglomerates.

Japanese youth, now more willing to embrace risk and pursue stock options over lifetime employment, are supported by a growing venture capital ecosystem. Large corporations are investing in startups through corporate venture capital, while new graduates are increasingly choosing tech startups over traditional companies. Japan's path forward lies not in reviving the R&D budgets of large firms but in nurturing startup swarms to revitalize the economy. Based on my experiences, Japan has never been better positioned to make a comeback, with major investments in AI, cloud, and science already showing promising results.

Executive Summary

This report comprehensively analyses Japan's current macroeconomic landscape. It focuses on advancements in key sectors, such as artificial intelligence, quantum technology, and digital assets.

As the world's fourth largest economy, prospects for Japan's growth rate are modest, with external demand and strong exports likely to drive it. Meanwhile, even though real GDP growth forecasts have been revised down from 0.9% in October 2023, to 0.3% in October 2024, inflation dynamics are improving (meaning prices are edging up) and wage growth increasing. However, challenges remain, notably the declining population, which poses long-term economic risks.

Japan's government is actively investing in innovation, particularly in quantum technology and digital assets. With significant public funding and a robust patent application rate, Japan ranks among the top nations in quantum advancements. The digital asset market is also evolving, with authorities establishing regulatory frameworks to support cryptocurrencies and stablecoins. Japan is also putting a lot of stock in tapping the benefits of AI—and what it could do for productivity amid the rapid ageing of the population, for example—to help fuel economic growth and bring societal benefits.

As such, while Japan faces structural challenges, it is well-positioned to leverage emerging technologies to remain competitive and foster long-term economic growth.

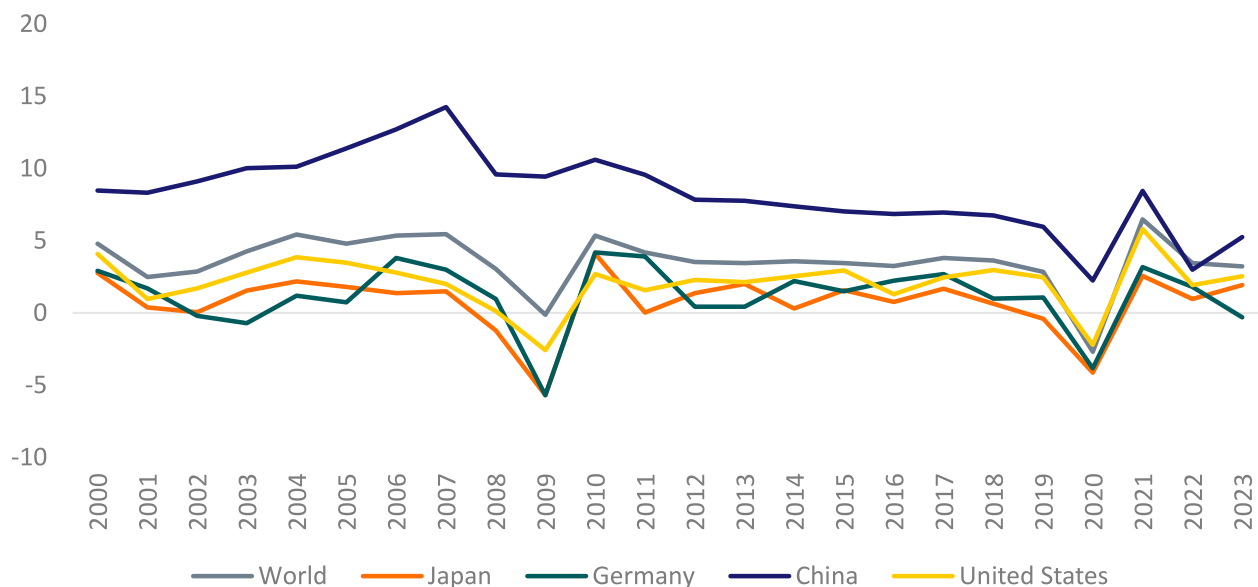
Macroeconomic Overview

The economy

Japan was the world's fourth largest economy as of 2023, just behind Germany in nominal US dollar terms. In October 2024, the International Monetary Fund (IMF) projected Japan to grow at 0.3% in 2024, revising the forecast down from 0.7% in their July 2024 update.

Real gross domestic product (GDP) growth has averaged around 0.7% over the last decades (2003–2023). And in July 2024, the International Monetary Fund (IMF) projected Japan to grow at 0.9% in October 2023, revising the forecast down to 0.7%. Positive economic developments nonetheless continue, and inflation dynamics and wage growth are improving (that is, inflation has been edging up with some pass-through to wages).

Figure 1. Real GDP Growth, 2000–2023



Source: International Monetary Fund, World Economic Outlook (April 2024).

Inflation dynamics

Japan has historically maintained one of the lowest interest rates globally, averaging 2.26% from 1972 to 2024. The Bank of Japan adopted a negative interest rate policy in January 2016, with rates as low as -0.10%, as part of its aggressive monetary easing to combat deflation and spur economic growth. In July 2024, however, the central bank raised interest rates to 0.25%, marking the end of the country's negative rate era and yield curve controls. **This was the first interest rate hike in Japan in 17 years.**

The move follows signs of moderate economic recovery and rising inflation. By September 2024, Japan's core inflation reached 2%, hitting the central bank's target, signalling the potential for further rate hikes. This rise in inflation was accompanied by wage growth, with average cash earnings increasing by 4.5% year-on-year (y-o-y) in June 2024—the highest in 30 years. Wages continued to rise by 3.6% y-o-y in July 2024, suggesting a solid pass-through of inflationary pressures to wages.

Figure 2. Bank of Japan Quantitative and Qualitative easing



Source: Reuters (March, 2024).

Note: BOJ = Bank of Japan, CPI = consumer price inflation.

Japan's inflation dynamics are turning around. **Core inflation, which excludes food prices, met the central bank's target of 2% in September 2024, marking an important milestone for the Bank of Japan's policy.** However, Japan's *core-core inflation*—a unique metric to Japan that excludes both food and energy—stood at 1.9% in July 2024, just below the target inflation rate for the first time since September 2022.

Declining population a challenge

The declining Japanese population continues to be a major macroeconomic concern in the medium and long term (IMF, 2024). The population has declined 2.3% in the past decade, from about 127 million to 124 million. In 2023, population levels were close to 1991 levels. In the next five years, population growth is expected to continue its downward trend (IMF, 2024). The proportion of the total population aged 25–64 is also projected to decrease. United Nations estimates indicate that this age group will represent 48.7% of the population in 2030, down from 55.7% in 2000 (UN, 2024).

The Stock Market

Japan's capital markets, among the largest and most developed globally, play a critical role in the economic framework. The Tokyo Stock Exchange is one of the largest in the world by market capitalization, and the stock market, represented by major indices such as the Nikkei 225 and the TOPIX, has benefited from improved corporate governance, higher dividends, and share buybacks.

A key characteristic of the capital markets has been the relatively low interest rates over the past two decades, driven by the Bank of Japan's prolonged monetary easing policies. These low rates have enabled corporations to borrow at historically low costs, fuelling investment and expansion, particularly among export-oriented companies. **However, with that shift away from negative interest rates noted above, observers are anticipating a recalibration in the financial environment, so much so that the Nikkei was at an all-time high in July 2024.**

Figure 3. Nikkei 225



Source: Investing.com (as of 24 October 2024).

The Japanese yen

Japan's currency, the yen, has experienced significant fluctuations in recent years, primarily influenced by shifts in monetary policy, inflation expectations, and global economic conditions. **Historically, the yen has been considered a safe haven**, with investors seeking it during global economic uncertainty or geopolitical tensions. **However, during 2022 and 2023, the yen weakened considerably**, reaching a 24-year low against the U.S. dollar. By 2024, as the Bank of Japan shifted towards higher interest rates and ending yield curve controls, the yen has shown signs of stabilizing, although volatility remains.

Figure 4. Japanese Yen/US Dollar



Source: Trading View.

Quantum Technology

Japan is also accelerating its efforts in quantum technology, joining other nations in the race to master this emerging area. **In 2022, the country announced a significant public investment of \$1.8 billion in funding for quantum technologies**, placing it among the top-10 globally for public investment in this sector. **Japan also ranks third worldwide in patent applications for quantum computer-related technologies**, accounting for 12.5% of all filings between 2010 and 2021 globally. Fujitsu Ltd. is one of the leading Japanese companies in this field (The Japan News, 2024).

The country is focusing on four main areas: quantum computing, quantum sensing, next-generation lasers, and quantum human resources development. Japan, as of April 2024, led with 20% of the global quantum technology-related patents granted, just behind the United States (37%). In 2023, the country launched its third quantum computer in partnership with several institutions, including Osaka University's Center for Quantum Information and Quantum Biology, RIKEN, and leading companies like Fujitsu, NTT Corporation, and QunaSys. By 2050, Japan aims to develop a fault-tolerant quantum computer under Moonshot Goal 6 (McKinsey Digital, 2024).

Figure 5: Overview of Japan's Quantum Efforts



Source: Quantum Technology Monitor, McKinsey (April 2024).

Key industry players such as Fujitsu and SKY Perfect JSAT are contributing to Japan's quantum advancements. Research hubs like RIKEN, supported by government funding, and Q-STAR, a collaboration platform uniting industry, government, and academia, are at the forefront of developments in quantum computing and communication technologies. Collaborations between the public and private sectors, such as the partnership between Fujitsu and RIKEN, are driving innovation. Together, they have developed platforms for hybrid quantum computing, which combines the computing power of a newly developed 64-qubit superconducting quantum computer with one of the world's largest 40-qubit quantum computer simulators, created by Fujitsu.

Additionally, the Japanese government has made significant investments in shared quantum computing initiatives. For instance, the University of Tokyo, supported by the Ministry of Economy, Trade, and Industry, is expanding its quantum research capabilities. The government's investment of \$31.7 million will fund the introduction of an IBM 127-qubit quantum computer to complement the university's existing 27-qubit model. This initiative emphasizes the importance of startups in driving innovation, encouraging a culture of experimentation, and creating intellectual capital, all while mobilizing resources from both the private sector and the government to create new markets (Govt of Japan, 2024).

Digital Assets

Japan was one of the first countries to recognize the potential of digital, decentralized systems like Bitcoin and started “mining” it early. In the early days of cryptocurrencies, Japan became a major global hub, with the exchange Mt. Gox processing millions of Bitcoin transactions. Even after Mt. Gox was hacked in 2014, Japan did not ban cryptocurrencies. Instead, the country introduced consumer protections, and by 2016, it officially recognized cryptocurrencies as a form of money (Cointelegraph, 2024).

According to Statista, Japan's digital assets market is projected to generate revenue of \$1.4 billion in 2024, with an expected slight decline in growth, reaching \$1.34 billion by 2025 (compound annual growth rate -4.49%). The average revenue per user is estimated at \$72.7 in 2024, with user penetration increasing from 16.95% in 2024 to 17.13% by 2025, representing about 19.43 million users. Despite slower growth, Japan remains a key player in the global digital assets landscape.

In 2023, the Bank of Japan launched a pilot program for a central bank digital currency (CBDC). Meanwhile, Japan's Financial Services Agency is working to create a supportive environment for digital money and crypto assets, aiming to build a digital society.

At the same time, Japan's private sector is pushing forward with projects in areas like stablecoins, security token trading, and international transactions using blockchain. Leading financial institutions and tech companies are driving these efforts, helping to strengthen the country's digital finance and blockchain landscape.

The private sector in Japan is playing a crucial role in driving innovation in digital assets by spearheading a range of initiatives across blockchain, stablecoins, and security tokens. Here are key private sector initiatives on digital assets in Japan:

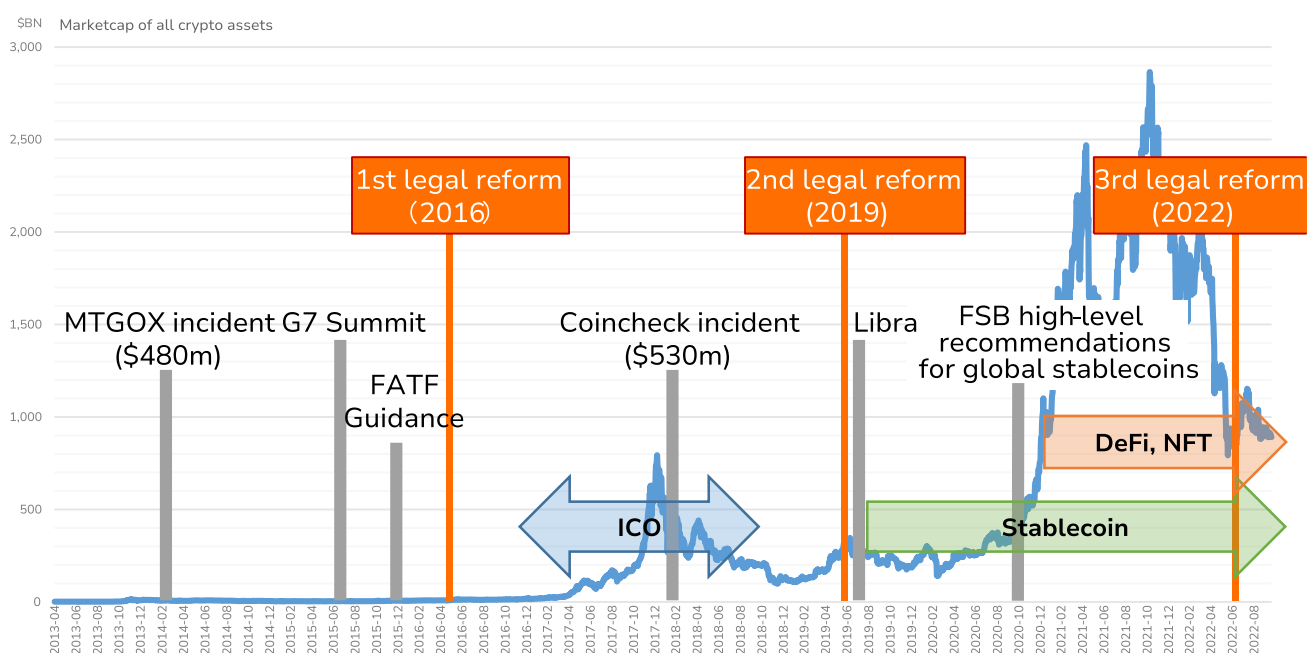
- **Stablecoin Partnership:** Nomura Holdings, Laser Digital, and GMO Internet Group are exploring the issuance of Japanese yen and U.S. dollar stablecoins in Japan (Nomura, 2024).
- **Security Token Trading:** Osaka Digital Exchange launched "START," Japan's first proprietary trading system (PTS) for security tokens, on December 25, 2023, creating a secondary market for security token trading (ODX, 2023).
- **Cross-Border Repo Transaction:** UBS, SBI, and DBS completed the world's first cross-border repo transaction using a digital bond on a public blockchain, as part of Singapore's MAS Project Guardian (SBI Digital Asset Holding, 2023).
- **Global Stablecoin Development:** Mitsubishi UFJ Trust and Banking is developing a global "National Stablecoin" using the Progmatic Coin platform, enabling secure cross-border transactions under Japan's amended Payment Services Act (Mitsubishi UFJ Trust and Banking Corporation, 2023).

Japan's Financial Services Agency plays a key role in regulating cryptocurrencies, in partnership with the Japan Virtual Currency Exchange Association and the Japan Security Token Offering Association. While cryptocurrencies are not considered legal tender in Japan, banks are increasingly adopting blockchain technology, and some are even launching their own digital coins. The Payment Services Act mandates that cryptocurrency exchanges must register with the Financial Services Agency, though there are no restrictions on citizens owning cryptocurrencies. A notable shift occurred in September 2023, when Japan proposed allowing investment firms to hold crypto assets, signalling a shift in the regulatory landscape (Cointelegraph, 2024).

Three Legal Reforms in Japan's Digital Asset Regulation

- 1. The first legal reform was in 2016**, which introduced a registration system for Crypto Asset Exchange Providers, marking Japan's initial regulatory response to the growing crypto asset market, and establishing a licensing framework for cryptocurrency exchanges. It aims to enhance investor protection and market integrity following incidents like the Mt.Gox hack, requiring exchanges to register with the Financial Services Agency and comply with anti-money laundering measures. This was due to the amendment of the Payment Services Act, in which the agency classified crypto assets as a means of payment.
- 2. The second reform came in 2019**, which expanded the regulatory framework to include new categories of digital assets and introduced stricter requirements for crypto asset service providers. It focused on improving consumer protection, enhancing operational transparency, and ensuring that exchanges implement robust security measures to safeguard user funds. This was due to the amendment of the Financial Instruments and Exchange Act, which classified digital assets with securities characteristics as security tokens (Electronically Recorded Transferable Rights).
- 3. The latest reform, introduced in 2022**, commenced regulations specifically for stablecoins, allowing for their issuance and use within the financial system. It established clear guidelines for stablecoin providers, including requirements for asset backing and consumer protection measures, thereby promoting the safe integration of stablecoins into the broader financial ecosystem while addressing concerns related to financial stability and regulatory oversight.

Figure 6. Development of the Crypto Asset Regulatory Framework in Japan



Source: Financial Services Agency Japan, 2022.

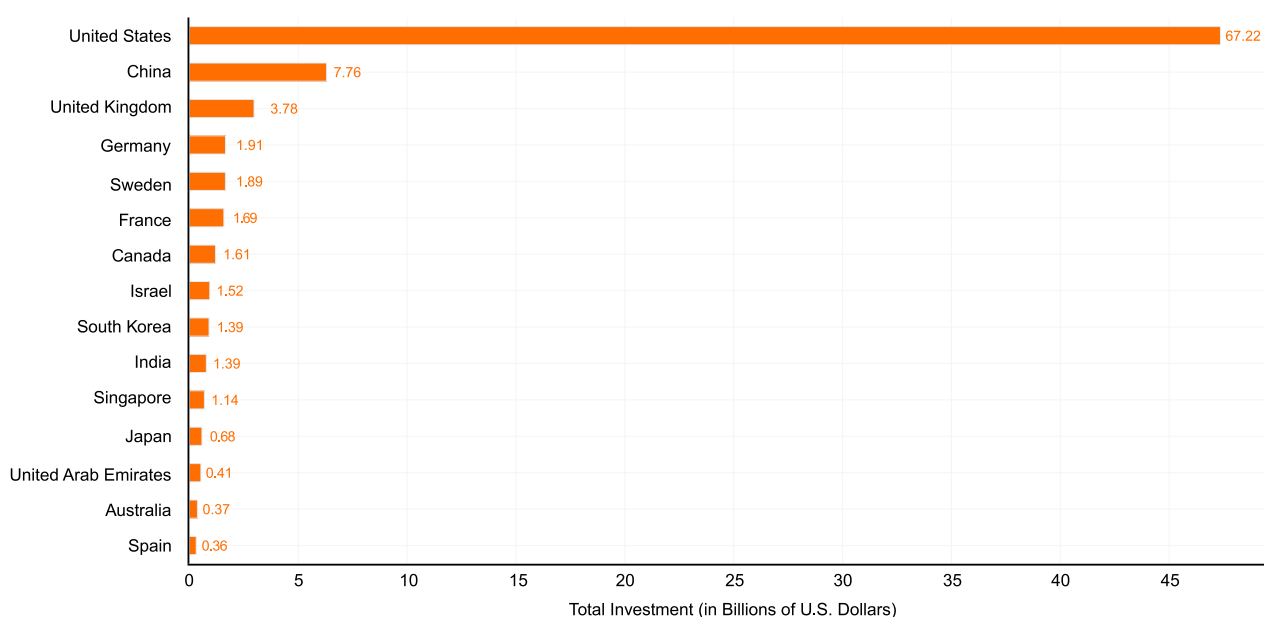
Artificial Intelligence

The AI landscape in Japan is significantly advancing, led by private sector companies, focusing on AI hardware, robotics and semiconductor production, and positioning the country as a key player globally. The implications of the country's shrinking workforce due to a declining birthrate and ageing population are driving these developments, with AI seen as a solution to fill labour shortages and maintain productivity levels.

The country's significant research and development expenditure ranked second globally. Alongside its fourth place ranking in manufacturing competitiveness business-friendly policies, a skilled workforce, and high productivity in technology and advanced manufacturing, this has made the country an attractive destination for foreign direct investment in the business processes industry.

The country's investment in AI has been bolstered by ventures like Mujin, which raised \$85 million to advance AI-driven robotics for logistics and manufacturing. However, Japan remains behind other advanced economies in private investments in AI, as of 2023.

Figure 7. Private Investments in AI, by Geography (US dollar billion)



Source: Quid, 2023.

The sections below highlight important initiatives in the public and private sectors that are advancing AI.

Public Sector Initiatives

Japan's AI market was estimated at US\$3.8 billion in 2022 and is expected to grow to US\$27.1 billion by 2032. A compound annual growth rate of 21.4% is expected from 2022 to 2032 (Spherical Insights, 2023).

The country's ageing population makes AI a top priority.

- a. **AI Strategy 2022:** The updated strategy builds on previous initiatives, aiming to position Japan as a leader in global AI development. The strategy outlines a vision for promoting AI as a tool to enhance quality of life, improve public services, and boost economic growth. It aims to create a society where AI is integrated into various sectors, including healthcare, agriculture, and transportation (Cabinet Office, 2022).
- b. **Society 5.0:** This initiative envisions a “super-smart society” where AI, the Internet of Things, robotics, and big data will transform every aspect of life, from infrastructure to healthcare. AI is central to achieving Society 5.0, particularly in addressing societal challenges like Japan's shrinking workforce and ageing population (Cabinet Office, 2015).

Japan's government has invested heavily in AI R&D. The Cabinet Office, along with the Ministry of Economy, Trade, and Industry, has allocated significant funds to support AI projects. Institutions such as the RIKEN Center for Advanced Intelligence Project focus on long-term research, and partnerships between universities, research institutions, and private firms have been promoted to accelerate innovation.

With Taiwan Semiconductor Manufacturing Co. (TSMC) establishing its first plant in Kumamoto to produce chips for clients like Sony and Renesas, Japan is bolstering its semiconductor industry to support AI and high-performance computing. Complementing these innovations, Japan's regulatory framework is evolving to support its ambition in AI. Initiatives such as Regulatory Sandbox and the establishment of the Digital Agency are fostering innovation while maintaining ethical standards. Furthermore, Japan's 2024 AI guidelines emphasize responsible AI use, creating a favourable environment for startups and foreign investors, and ensuring the country remains agile in the rapidly changing AI landscape.

Private Sector Initiatives

The private sector is making significant strides in AI hardware development, with major investments and innovative projects aimed at enhancing the country's technological capabilities. Below are notable initiatives undertaken by key companies:

1. **Microsoft** is making its largest investment in Japan by committing to \$2.9 billion in data centres across the country by 2025 to enhance AI computing capabilities. This investment includes the installation of advanced AI chips at two data centres. Additionally, Microsoft has launched a workforce training program to equip 3 million workers with AI skills over the next three years. As part of its expansion, the company will establish a new AI and robotics research lab in Tokyo, backed by a funding commitment of \$9.9 million. This lab will collaborate on research projects with the University of Tokyo, Keio University, and Carnegie Mellon University. Furthermore, Microsoft will partner with the Japanese government to improve cybersecurity measures in response to global threats.
2. The **TSMC** manufacturing plant in Kumamoto plans to produce chips for clients such as Sony and Renesas by the end of 2024. To support its semiconductor industry, the Japanese government has announced a \$4.86 billion subsidy for a second TSMC plant. The new Kumamoto facility will initially focus on producing chips in the 12 to 28 nanometers (nm) range, which are suitable for automotive and consumer electronics. A second facility, with investment from Toyota Motor, will concentrate on advanced 6nm and 7 nm chips intended for industrial and high-performance computing applications.
3. **NEC Corporation** (NEC) has significantly advanced developments of innovative AI technologies that enable robots to function effectively in complex environments, reducing reliance on manual labour. Utilizing a concept called "World Models," NEC's robots can predict hidden areas and anticipate the outcomes of their actions, greatly enhancing task accuracy in operations such as pushing and pulling objects. This cutting-edge technology is expected to be introduced in logistics warehouses by the end of 2024, leading to improved productivity and better working conditions.
4. **Mujin**, a leader in intelligent robotics for manufacturing and logistics, has raised \$85 million in Series C funding to support its expansion efforts. This will enhance development of the MujinController, a technology that transforms robots from various manufacturers into smart machines capable of automating complex tasks. Mujin's innovative solutions tackle challenges such as order picking, container unloading, and palletizing, making a significant impact in industries like e-commerce and automotive.
5. **Rapidus**, a Japanese chipmaker, is set to establish a fully automated production line in northern Japan that will leverage robots and AI to manufacture advanced 2nm chips for AI applications. The company anticipates starting mass production by 2027, asserting that this automation will significantly reduce production times and allow for chip deliveries to be three times faster than those of its competitors. The external structure of the factory is expected to be completed by October, with the EUV lithography system scheduled to arrive in December 2024.

The use of **AI-powered automation** in industries such as manufacturing, logistics, and retail, as noted, is expected to mitigate the impact of a reduced labour force. Additionally, AI will be critical in re-skilling workers for the digital economy, with an emphasis on education and vocational training to prepare Japan's workforce for AI-integrated environments.

AI regulatory framework

Japan has no specific rules regarding AI regulation. It is instead taking an indirect approach to fostering innovation while minimizing harm. As of September 2024, the country has consolidated three existing guidelines, which are not legally required, to encourage developers, providers, and businesses using AI systems to voluntarily follow them. This is done by aligning with widely accepted AI principles and taking a risk-based approach to using AI.

The guidelines promote "agile governance," where businesses and stakeholders continuously assess risks, set goals, design systems, and evaluate their operations across various sectors like regulations, infrastructure, and markets. Japan also introduced the Hiroshima International Guiding Principles to establish global guidelines for safe, secure, and trustworthy AI. The country's AI Strategy Council also proposed regulatory approaches to maximize AI's benefits while minimizing risks. A working group has also proposed a new law, the "Basic Act on the Advancement of Responsible AI," which would regulate certain generative AI models. This law would require developers of designated AI systems to meet specific operational and reporting standards. The government would oversee compliance, with penalties for violations, marking a shift from Japan's current "soft law" approach to a more formal regulatory framework (White Case, 2024).

Overview of Japan's AI guidelines:

- **Human-Centric and Sustainable Development:** AI should respect human dignity, promote diversity and inclusion, and contribute to societal sustainability, addressing global challenges like environmental issues.
- **Risk-Based Governance:** AI use must be safe, fair, transparent, and secure, with protections for privacy and accountability for its outcomes. Businesses are encouraged to adopt a proactive approach to managing AI risks throughout its lifecycle.
- **Collaborative Responsibility:** AI developers, providers, and users each have distinct roles in ensuring the ethical development and deployment of AI, working together to mitigate risks and maximize societal benefits.

Conclusion

In conclusion, Japan's economic outlook is modest, categorized by cautious optimism amid structural challenges. The government's proactive approach towards innovation in quantum technology, digital assets and AI reflects a commitment to maintaining competitiveness in the global economy. However, the persistent issue of population decline necessitates urgent policy interventions to ensure sustainable growth. By fostering advancements in AI and supporting emerging technologies, Japan can navigate its economic challenges while enhancing its position as a leader in technological innovation.

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