EAI-KF-API Working Paper

Korea-Japan Joint Work on World 2050 ⑪

Declining Population, Increasing Human-Machine Teaming

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I. Introduction

The population decline, a pressing issue attributed to aging and low birth rates, is a common and urgent challenge for Japan and South Korea. Japan's population peaked in 2008; since then, it has declined for 15 consecutive years. In 2023, the Japanese elderly population (aged 65 or over) reached 29.1% — the highest in the world (Cabinet Office 2024). Similarly, South Korea's population peaked in 2020 and has decreased. As of 2024, its elderly population is projected to account for 19.2% of the total population (Statistics Korea 2024).

Japan is at the forefront among aging countries. As of 2023, Japan's total population—both Japanese and foreign residents—is 124.88 million, a decrease of about 530,000 from 2022. Although the number of foreign residents has increased at a record pace, the number of Japanese nationals alone decreased to 121.56 million, by 86 thousand people (-0.7%) from 2022, the largest decrease ever (*NHK* 2024).

This article will discuss the common challenges brought about by population decline in Japan and South Korea; specific challenges for Japan; the relationship between population decline and national power; and issues for future cooperation between Japan and South Korea towards 2050.

II. Common Challenges

Japan and South Korea face several common challenges regarding population decline. First is the heavy burden of the social security system on national finances. The number of elderly people continues to rise while the working-age population rapidly decreases. Working-age population supports the social security system based on intergenerational support. Aging and population decline are becoming enormous burdens for Japanese fiscal policy.

Japan's social security expenses account for 22.4% of its GDP in 2024. Given the severe security situation involving North Korea, China, and Russia, the Japanese government aims to expand

its defense expenditure to around 2% of GDP. Hence, Japan spends around 11 times of its defense spending on its social security.

Second, it is becoming more difficult to recruit young first responders. Japan and South Korea face common security threats—North Korea, China, and Russia. Also, the two nations suffer from natural disasters, including typhoons and earthquakes. In order to respond to national security threats and natural disasters, maintaining the number of first responders, such as military personnel, firefighters, and law enforcement officials (police and coastguard), is essential. Given the population decline, crisis management bodies are competing to hire skilled talent. The new challenge for them is to attract female first responders, considering the emergence of requirements for diversity and inclusion. Japan's Self-Defense Forces (SDF) tried to recruit 20,000 officers in 2023, but they only managed to hire 10,000 (Cabinet Secretariat of Japan 2024).

Third is Aging China. Similar to Japan and South Korea, China is also struggling with an aging society and population decline. Chinese population started to decline in 2022. China's rapid promotion of self-reliance and indigenous innovation in the medical equipment sector poses potential economic security risks for the Japanese government and companies. Some Japanese firms view China's "very warm welcome" to medical sector investments, followed by a push for domestic independence, as a threat to their existing operations. For both Japan and South Korea, the reality of population decline signals an urgent need to develop and deploy robots and AI. Meanwhile, China is rapidly enhancing its robot technology. As with EV batteries and solar panels, issues of economic security arise if reliance on Chinese robotics technology becomes excessive.

Fourth, Japan and South Korea share concerns about the disappearance of local municipalities. Local communities risk losing social and medical infrastructure, as well as social security services, due to depopulation.

III. Impact of Predicting "Potentially Disappearing Municipalities"

In Japan, population decline is particularly serious in rural areas (as well as in some wards of Tokyo) with low birth rates. Depopulation and a shortage of manpower raise the question of how to maintain and develop local service provisions.

Of the 1,718 municipalities in Japan, more than half (885, or about 52%) are officially categorized as depopulated municipalities, making the maintenance of basic services a nationwide issue. Because of lower population density and labor shortages, businesses are being forced to downsize or withdraw from certain areas. In depopulated areas, it is increasingly difficult to provide essential services, leaving many elderly people as "shopping refugees." Industries most affected include wholesale and retail, logistics, nursing care, healthcare, education, childcare, after-school care, housekeeping support, funeral services, gas stations, and local transportation. Profit-driven companies often struggle to continue operating in areas with declining populations, while local governments' ability to provide basic services is also limited.

In 2014, a group of experts conducted an analysis of the sustainability of 1,729 municipalities across Japan. The group, Japan Policy Council, chaired by former Iwate Prefecture Governor Hiroya Masuda, indicated that 896 municipalities could disappear between 2010 and 2040. That estimate was received in Japan with shock.

Ten years later, an analysis by a largely similar group of the experts—the Population Strategy Council (Chairman: Akio Mimura, Honorary Chairman of the Japan Chamber of Commerce and Industry; Vice Chairman: Hiroya Masuda)—suggests there could be 744 municipalities at risk of disappearing by 2050 . The decrease in the number of potentially disappearing municipalities over the past decade is attributed to an influx of foreign residents and increased competition among municipalities to attract younger populations.

However, Japan's fundamental problems of declining population, an aging society, and low birth rates remain unsolved. A study of population data from 1980 to 2020 shows that the population of women aged 20–39 has already halved in 879 municipalities.

The Population Strategy Council also argues that Japan will be forced into continuous downsizing and retrenchment. Although these disappearing municipalities pose a threat to local governments and traditional Japanese values, they do not necessarily spell the decline of Japan's national power overall.

It is often said that population decline can lead to the decline of national power. This narrative, however, is worth considering.

IV. Population Decline and National Power

Traditionally, when population issues were discussed, the major issue was overpopulation (Tadokoro 2016). A classic theory is Malthus's argument in 19th Century that although population and labor increase, the amount of arable land does not grow at the same pace, resulting in a declining yield per person. Classical realists in international politics, such as Hans Morgenthau, also generally viewed population as a national resource.

From the 19th century onward, however, the premise of Malthusian arguments that agriculture is the basis of productivity largely collapsed. The relationship between population and national power became more nuanced due to the Industrial Revolution and the expansion of productivity through innovation. These innovations enabled a few European countries to gain considerable national power and to exert enormous influence worldwide.

However, the relationship between population size and national power is not so obvious. National wealth is no longer limited to agriculture or industry; services such as finance and ICT also play pivotal roles in generating national wealth. What matters most is achieving high productivity that can outpace population decline through continuous innovation.

As one indicator for observing innovation capabilities, the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations, publishes the Global Innovation

Index (GII) every year (WIPO 2024). The GII was originally developed in 2007 with the support of INSEAD. The GII is a ranking of the innovation capabilities and results of world economies. It measures innovation based on criteria that consider national inputs on institutions, business/regulatory environment, education, ICT infrastructure, market sophistication (credit, investment, and trade), and outputs of knowledge and creative services.[1] In the GII 2024, Switzerland is ranked first, Sweden second, and Singapore fourth. As such, countries with relatively small populations—such as Switzerland (8 million), Sweden (11 million), and Singapore (6 million)—demonstrate development models powered by continuous innovation. Japan, the 13th in the GII, and South Korea, the 6th, can learn from those countries with relatively small populations and continuous innovation.

For instance, Singapore built a robust industrial foundation in financial services and advanced technologies such as semiconductors and biotechnology. Singapore also benefited from welcoming immigrants as knowledge workers and young labor from Asia and the Middle East. Out of approximately 6 million people in Singapore, 3.6 million are Singaporean citizens (around 60%), while the remaining 40% are permanent residents (originally immigrants, 9%) and non-residents (31%), including foreign workforces, their dependents, and international students (National Population and Talent Division 2024).

Furthermore, Daron Acemoglu empirically argued that there was no negative correlation between population aging and per capita GDP growth; in actuality, there was a positive correlation. Since the early 1990s or 2000s, many have expressed concerns about the adverse effects of aging in developed countries, yet Acemoglu and Restrepo's research indicates there was no evidence of a negative relationship between aging and GDP per capita (1990–2015); on the contrary, the relationship is significantly positive (Acemoglu and Restrepo 2017). Acemoglu's research suggests that the adoption of robotics and machines, as well as AI, plays a critical role in the positive correlation.

V. Future Cooperation Towards 2050

As discussed, both Japan and South Korea face population decline and aging, and they can exchange lessons learned and good practices of effective policies to tackle these challenges. There are common areas to share lessons learned: the birth rate of their own nationals, immigration and integration, and human-machine teaming.

To raise the birth rate, the Japanese government has been trying to create a society that offers bright hopes for the future, encouraging marriage, childbearing, and child-rearing. This includes supporting individuals' pursuit of happiness and raising incomes for younger generations. To facilitate such policies, the Japanese government launched the Children and Families Agency in April 2023. Such policies, however, only focus on Japanese citizens.

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[1] The GII uses both objective data drawn from various public and private sources, such as the World Bank and the International Telecommunication Union (ITU), and subjective data drawn from the World Economic Forum's annual Executive Opinion Survey.

Towards 2050, it's obvious that Japan, as well as South Korea, cannot sustain the societies only by Japanese or South Korean citizens—both nations need to foster a collaborative society with immigrants. Japan's foreign-resident population reached 3.32 million in 2023, an increase of about 330,000 from the previous year (+11%). Many of these foreign nationals come as "skilled trainees" who work in agriculture, manufacturing, and the service industries.

In addition to continuing these traditional efforts, Japan and South Korea have huge potential to promote robotics and automation—this will surely be useful for other aging nations globally. In such efforts, a key concept will be "human-machine teaming."

VI. Robotics, Automation, and Human-Machine Teaming

As robotics and automation technologies that replace human labor advance, government entities, companies, and healthcare facilities can increasingly automate production processes. Countries experiencing rapid aging and labor shortages tend to adopt robotics more readily, thereby boosting productivity and achieving positive economic effects. When labor becomes scarce, capital investment in labor-saving innovations increases, making these new technologies more productive. Consequently, population decline does not necessarily hinder economic growth; if it triggers new technologies and increases productivity, it can even foster economic expansion (Acemoglu and Restrepo 2018).

Healthcare services, such as hospitals and elderly care facilities, are known as one of the most labor-intensive industries. Another famous industry that traditionally requires a human workforce is the automobile industry. Since the emergence of electronic vehicles (EV), automobile industries are not just utilizing robots but also fully automating the production cycle, with very limited human monitoring. Unlike the automobile industry, in healthcare services, human care is required in medical facilities, hospitals, or long-term nursing facilities. In such facilities, human-machine teaming is the key to continuing the required services in an aging society.

Especially in healthcare facilities, Japan and South Korea have been actively developing and deploying robotics to address workforce shortages and increase productivity. Japan has been developing robots to care for elderly people for over two decades, with public and private investment accelerating markedly in the 2010s (Wright 2023). The Japanese government, particularly the Ministry of Economy, Trade and Industry (METI) and the Ministry of Health, Labour and Welfare (MHLW), has endorsed the use of robots and AI in nursing and medical care facilities. In labor-intensive nursing care, technologies like image recognition AI, sensors, and robots can help deliver high-quality services with fewer workers. Recently, affordable robotics in healthcare industries are becoming available in Japan and South Korea. Healthcare industries in the two nations promoted the implementation of automation in healthcare facilities—consequently, those companies have been constantly expanding their business in the global healthcare industry.

With regard to human-machine teaming in hospitals, Japanese companies developed several care robots, such as Hug, a lifting robot; Paro, a robotic seal; and Pepper, a humanoid robot. Hug was

meant to prevent care workers from having to manually lift residents. Paro offers a robotic form of animal therapy, while also acting as a distraction aid for some people with dementia who made repeated demands of staff throughout the day. Pepper, initially known as a simple humanoid robot, used in nursing care homes to run recreational exercise sessions so that staff would be freed for other duties (Wright 2023). HOSPI, manufactured by Panasonic, is an autonomous delivery robot used in hospitals to transport fragile and bulky medicine, medical specimens and patients' case notes. HOSPI has been implemented at the Changi General Hospital in Singapore since 2015. HOSPI is equipped with sensors and programmed with the hospital's map data to avoid obstacles, such as patients in wheelchairs, and complete deliveries with minimal supervision by humans. The HOSPI autonomous robot communicates and relays information on its whereabouts to the control center, enabling its location to be monitored and recorded 24/7 (*Panasonic Newsroom* 2015).

In South Korea, several facilities have introduced companion robots that provide basic social interaction and remind elderly individuals to take medications or perform daily exercises. LG Electronics developed LG CLOi, which is a service robot to assist with tasks such as delivering medications, carrying medical supplies, and guiding patients through hospital corridors. Several hospitals in South Korea have tested or are in the process of adopting these robots to reduce staff workload and infection risks (*LG Press Release* 2022). Many major hospitals in South Korea, such as Severance Hospital and Samsung Medical Center, have adopted the Da Vinci robotic surgical system, invented in the United States, for procedures ranging from urology to cardiothoracic surgery (Bae 2008). These systems enable more precise, minimally invasive procedures, resulting in faster patient recovery and reduced labor demands.

Rehabilitation is another area that requires human workforces. South Korean and Japanese companies and research institutions have developed exoskeletons, or wearable robotic suits, that aid in the rehabilitation process for stroke patients or individuals with mobility impairments. By supporting the user's body and providing guided movement, these exoskeletons can accelerate recovery and improve patient independence. Startup companies, such as CYBERDYNE, a company spun off from Tsukuba University in Japan (Cyberdyne n.d.), and Angel Robotics in Seoul, developed gait-training robots that help patients with walking difficulties regain walking ability (Angel Robotics n.d.).

Some robots also incorporate AI-powered monitoring systems to track vital signs or detect falls. Startups are working with local governments and nursing facilities to test AI-driven robots that can support routine caregiving tasks—such as serving meals, assisting with hygiene, and alerting medical staff to emergencies—thereby reducing the burden on human caregivers.

As part of South Korea's Digital New Deal policy, which was launched in 2020, the ROK government has invested in AI, IoT, and robotics solutions to modernize the healthcare sector. This includes funding research on telemedicine platforms that integrate robotic support, enabling remote monitoring and intervention, particularly valuable in rural or understaffed regions. Korean Universities, private tech firms, and medical centers often collaborate to develop and pilot advanced

robotics solutions. KT and The Korea Advanced Institute of Science and Technology (KAIST), for instance, have partnered with local hospitals to design next-generation healthcare robots for use in surgical theaters and long-term care settings (*Korea Tech Today* 2021).

Implementing robots and automation to promote human-machine teaming is not only useful to lighten the workload for medical professionals; it can also standardize and even improve care quality and efficiency. Moreover, these innovations reduce the risk of infections and injuries for medical staff, while allowing caregivers to focus on higher-level patient needs—such as personalized care, patient communication, and emotional support.

VII. Conclusion

Japan and South Korea face significant challenges due to population decline, including the heavy burden of the social security system on national finances, the recruitment of young first responders, the Aging China, and the disappearing local municipalities. Nonetheless, historical examples and contemporary research suggest that a shrinking labor force can spur innovation and raise productivity, mitigating some of the presumed negative effects. The key lies in continuing innovation and collaborative efforts—not only between the public and private sectors but also between nations facing similar demographic shifts. As both Japan and South Korea look toward 2050, in addition to continuing tireless efforts to raise birth rates and foster collaborative societies with immigrants, the role of human-machine teaming is critical in shaping their socioeconomic futures. ■

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