Fertility decline and economic growth challenges: Japan's struggle amid a demographic crisis

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Abstract
This study examines the impact of demographic factors, particularly declining fertility rates and an aging population, on Japan's economic growth from 1960 to 2022. Additionally, it analyzes key macroeconomic variables, including healthcare expenditure, interest rates, and inflation, that influence the country's economy. Using quantitative time-series data and the Vector Error Correction Model (VECM), this research evaluates the short- and long-term effects of these variables on economic growth. The findings indicate that, in the long run, population aging and high interest rates significantly negatively affect economic growth. In contrast, healthcare expenditure and moderate inflation have a positive impact. Population aging slows economic expansion by increasing pension and healthcare costs, while high interest rates discourage investment and consumption. Conversely, healthcare expenditure, as an investment in human capital, enhances labor productivity, and moderate inflation stimulates economic activity by promoting consumption and investment. However, in the short term, none of these variables exhibit a significant impact on economic growth, suggesting that policy measures and demographic changes require time to influence the broader economy.

Keywords: *Economic growth, Fertility, Health expenditure, Inflation, Interest rate, Population aging*

JEL Classification: F64, J11, J13

INTRODUCTION

Population aging is one of Japan's most significant demographic challenges, closely linked to its unique cultural values. This phenomenon affects the economy as well as the country's social and cultural structures. With a long-standing tradition of respecting older adults, Japan is addressing this challenge in ways that reflect its cultural principles,

including reverence for elders, collectivism, and community harmony. Older adults are regarded as custodians of traditional values and family wisdom, a respect that is evident in annual celebrations such as Elderly Respect Day (*Keirō no Hi*) (Sugimoto, 2014).

However, changes in modern family structures and increasing urbanization have shifted elder care responsibilities from families to communities and formal care systems. In response, innovations such as modern nursing homes and humanoid robots have been developed to support older adults, demonstrating the adaptation of traditional cultural values to contemporary needs. Additionally, older adults play a crucial role in preserving cultural heritage, engaging in practices such as the tea ceremony and ikebana. Nevertheless, younger generations are increasingly drawn to modern lifestyles, posing a challenge to the sustainability of these traditions.

Beyond their cultural significance, the older population also plays a vital role in Japan's economy. Many older adults remain actively employed, while industries catering to healthcare and entertainment increasingly target this demographic. By integrating traditional values with modern innovations, Japan continues to address the challenges of an aging population while preserving social harmony and cultural identity (United Nations, 2023).

The demographic transition toward an aging population, combined with declining fertility rates, represents a major issue for Japan. Over the past three decades, the country's fertility rate has remained below 1.5, reaching a record low of 1.26 in 2022. As of 2022, Japan's population stood at 124.9 million, but it is projected to decline by approximately 30% to 87.0 million by 2070 (see Figure 1).

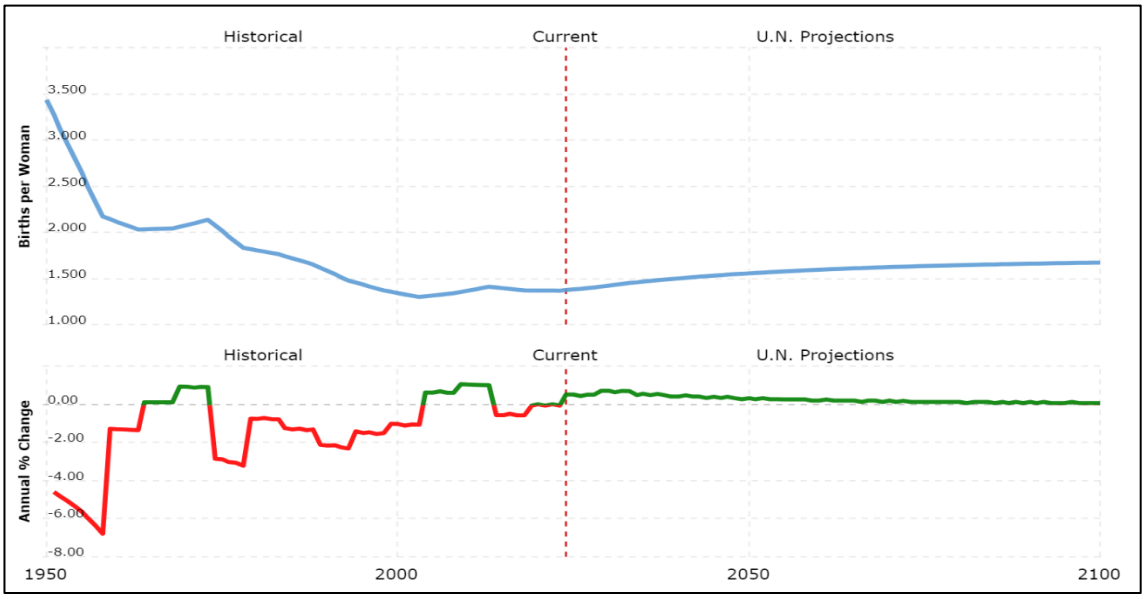

Figure 1. Trend of fertility rate in Japan 1950-2050
Source: United Nations, 2023

Japan's economy faces significant demographic challenges, primarily driven by declining fertility rates and an aging population. These factors profoundly affect economic growth, labor market dynamics, and public finances. Since 1950, Japan's fertility rate has declined from an average of 3.43 children per woman to 1.37 in 2023, reflecting a long-term trend of decreasing birth rates over several decades (United Nations, 2023). Simultaneously, rising life expectancy has accelerated a demographic transition that places Japan in a unique position among developed nations. Unlike the

United States, which has been able to adjust its healthcare spending to accommodate an aging population gradually, Japan encountered these demographic shifts much earlier and at a faster pace, intensifying economic and social pressures.

The aging population is another critical factor shaping Japan's economic trajectory. Between 1960 and 2022, the proportion of Japanese citizens aged 65 and older rose dramatically from 5.79% to 29.29% (World Bank, 2023b). This rapid increase has significantly heightened healthcare costs and posed further challenges to economic growth. Meanwhile, Japan's life expectancy increased from 67.5 years in 1960 to 85.15 years in 2022, one of the highest in the world (World Bank, 2023a). However, the combination of low fertility rates and an aging population has led to a shrinking workforce, constraining economic productivity and placing additional pressure on younger generations to support older adults. This demographic reality is further complicated by Japan's historically low birth rates and family structure dynamics (Hong & Schneider, 2020; Lopreite & Zhu, 2020; Muto et al., 2016).

As the elderly population expands, so does the demand for healthcare and social services. Rising healthcare expenditures for the aging population have become a defining feature of Japan's economic landscape—an issue faced by many countries but with particular intensity in Japan (Braendle & Colombier, 2016; Murthy & Okunade, 2016). Research consistently indicates a strong correlation between healthcare expenditure and economic growth, a relationship observed in both developed and developing nations (Beylik et al., 2022; Chakroun, 2024; Sharma, 2018). However, Japan's exceptionally high rate of population aging has led to an increased prevalence of chronic diseases and a growing demand for long-term care, posing significant challenges to the sustainability of its healthcare system and necessitating substantial financial resources (Feng et al., 2020).

While increased healthcare expenditure is costly, it has also played a crucial role in supporting Japan's high life expectancy. Investments in medical products and long-term care services have directly contributed to improvements in public health, fostering a healthier and more productive workforce (Braendle & Colombier, 2016). A healthier workforce enhances economic growth by improving labor quality and productivity, which is particularly important as Japan faces a shrinking labor pool due to persistently low birth rates (Álvarez-Gálvez & Jaime-Castillo, 2018; Linden & Ray, 2017). However, despite government initiatives such as childcare subsidies aimed at increasing birth rates, Japan's fertility rate continues to decline. This trend suggests that elderly citizens may face challenges in receiving familial support, further straining social services.

Another consequence of Japan's demographic shift is an impending labor shortage as the country nears the Lewis Turning Point—a stage in economic development where surplus labor from rural areas is depleted, leading to wage increases and a potential decline in global competitiveness (International Monetary Fund, 2023a). By 2050, Japan is projected to have the world's oldest population, with the proportion of citizens above retirement age expected to nearly triple from 9.6% in 2015 to 27.6% in 2050. Concurrently, the elderly dependency ratio—the ratio of elderly individuals to the working-age population—is expected to rise sharply, increasing from 54.5% in 2015 to 71.07% by 2022 (United Nations Population Division, 2023). These demographic changes have direct implications for economic productivity and labor costs, further exacerbating Japan's economic challenges.

Signs of economic strain are already evident. Japan experienced a GDP contraction at an annualized rate of 0.4% in the last quarter of 2023, following a 3.3% contraction in

the previous quarter—meeting the technical definition of a recession. Key factors contributing to this economic downturn include weak domestic consumption, rising healthcare expenditures for older adults, and the combined effects of low interest rates and inflationary pressures (International Monetary Fund, 2023b). Once the world's third-largest economy, Japan now ranks fourth behind Germany. These economic pressures, alongside ineffective monetary policies and demographic challenges, have constrained Japan's ability to stimulate growth through traditional economic mechanisms.

This study, therefore, aims to analyze the effects of Japan's demographic transition and economic recession, with a particular focus on how declining fertility rates and population aging impact economic growth. Special attention is given to labor market dynamics, public spending, and healthcare costs. Research on OECD countries by Amiri & Ventelou (2012) highlights a bidirectional relationship between GDP and healthcare spending, indicating that healthcare expenditure both influences and is influenced by economic growth. Similarly, Ämiri & Linden (2016) found that, across most OECD countries from 1970 to 2012, economic growth and aggregate healthcare spending were mutually reinforcing. Further supporting this relationship, Halıcı-Tülüce et al. (2016) identified a reciprocal link between health expenditure and economic growth in both low- and high-income economies.

Extensive research has examined the broader economic impacts of aging and healthcare spending. Chaabouni & Saidi (2017) identified a bidirectional relationship between health expenditure and economic growth across 51 countries of varying income levels from 1995 to 2013. Meanwhile, Sfakianakis et al. (2021) and Younsi et al. (2016) highlighted how declining fertility rates and population aging contribute to higher unemployment and increased private health insurance costs, both of which negatively affect economic growth. These findings are particularly relevant to Japan, where the combination of an aging population and low birth rates places significant constraints on the economy, particularly through rising healthcare costs and declining labor force participation.

Additional research indicates that while government healthcare spending is strongly associated with GDP growth, excessive healthcare expenditures can inversely impact economic growth when they become fiscally unsustainable. Lorenzoni et al. (2019) project that health spending will continue to rise until at least 2030, concluding that an increasing share of healthcare expenditure in GDP could slow economic growth, especially in countries with high debt levels. Similarly, Behera and Dash (2019) found that while tax revenue and population aging correlate positively with healthcare spending, high budget deficits, and debt servicing requirements tend to suppress key economic growth indicators. Karra et al. (2017) further examined the impact of fertility declines on economic growth, suggesting that lower fertility rates may enhance productivity by reducing dependency ratios.

In East Asia, studies have shown that reduced fertility can contribute to economic growth by improving human capital. For example, Bloom et al. (2024) found that fertility declines in developing countries support economic growth through increased labor force participation and greater investment in education. Likewise, Cervellati & Sunde (2015) argued that rising life expectancy enhances labor productivity, thereby positively influencing GDP per worker. These findings underscore the complex relationship between demographic shifts, health expenditures, and economic performance in high-income countries.

A study by Miles (2023) explored the effects of increasing life expectancy on fertility and economic growth, concluding that while longevity improvements have a positive effect on economic growth, the overall impact remains modest. Meanwhile, research by Bloom, Kuhn, et al. (2024) found that in high-income countries, fertility increases are often linked to reductions in childcare costs, which in turn support human capital development. This relationship is particularly relevant to Japan, where high childcare costs and work-life balance challenges contribute to low birth rates, potentially hindering human capital investment and economic growth.

While substantial research has explored the links between health expenditure and economic growth, a critical gap remains in understanding how these dynamics unfold in Japan's unique demographic context. The country's rapid aging and persistently low fertility rates present distinct economic challenges, making it imperative to examine their dual effects on labor market dynamics and fiscal policy. Additionally, limited research has explored the interactions between Japan's monetary policies, inflation control measures, and demographic shifts—factors that could provide valuable insights into sustaining long-term economic growth. Addressing these gaps is essential for assessing Japan's economic resilience and informing policy solutions tailored to its structural-demographic challenges.

Japan is undergoing significant demographic shifts, including declining fertility rates and an aging population, both of which have drawn considerable attention due to their implications for economic growth. Within the theoretical framework of demographic transition, declining fertility rates are a primary factor contributing to slower population growth and a potential reduction in the productive workforce in the future. Population aging is also a major concern, as it increases the proportion of elderly individuals who require healthcare and pension support, placing additional strain on healthcare systems and public budgets. This, in turn, may limit the resources available for sectors that drive economic growth.

Rising healthcare expenditures in response to population aging also play a crucial role in shaping Japan's economic dynamics. Additionally, inflation and interest rates influence the relationship between demographic change and economic growth by affecting consumption, investment, and monetary policy decisions. Understanding these interconnected factors is essential for assessing Japan's long-term economic prospects.

This conceptual framework (Figure 2) illustrates the relationship between demographic and macroeconomic variables and their impact on economic growth in Japan. From a demographic perspective, the declining fertility rate reduces the future productive population, thereby limiting the potential for economic growth. Simultaneously, population aging presents a significant challenge, as an increasing number of older adults require healthcare and pension support, placing substantial pressure on public budgets and constraining labor productivity. These two demographic trends are interrelated, creating complex dynamics that significantly influence the economic structure.

Beyond demographic variables, the framework incorporates key macroeconomic factors—including healthcare expenditure, inflation, and interest rates—that mediate the impact of demographic shifts on economic growth. Healthcare expenditure is regarded as an investment in human capital, as a healthier population tends to be more productive and capable of making sustained economic contributions. Moderate inflation can stimulate economic activity by encouraging consumption and investment; however, excessively high or low inflation can destabilize the economy. Similarly, high interest rates can

suppress economic growth by discouraging consumption and investment, whereas low interest rates can foster economic expansion if managed effectively.

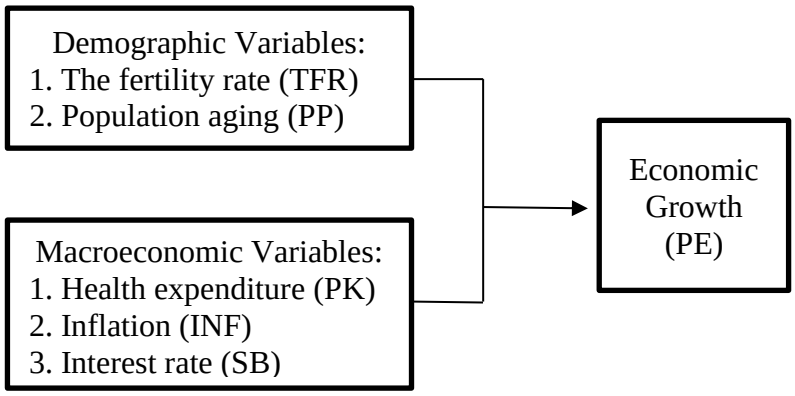

Figure 2 Conceptual framework

The interaction between demographic and macroeconomic variables reflects a complex relationship. For instance, population aging is likely to drive up healthcare spending, while declining fertility rates may lead to lower long-term consumption levels. These dynamics collectively shape economic growth, with factors such as population aging and high interest rates exerting a negative influence, while healthcare investment and moderate inflation contribute positively. By understanding these interconnections, policymakers can implement more effective strategies—such as targeted investments in healthcare, inflation control measures, and interest rate management—to address demographic challenges and sustain Japan's economic growth in the future.

METHODS

This study examines the relationship between demographic variables—specifically fertility rates and population aging—and macroeconomic variables, including healthcare expenditure, interest rates, and inflation in Japan from 1960 to 2022. These demographic changes, characterized by declining fertility and increasing population aging, as well as monetary policy adjustments, have significantly influenced Japan's macroeconomic performance.

The study employs a quantitative research approach using time-series data covering the period from 1960 to 2022. The data is sourced from the International Monetary Fund (2023a, 2023b), the United Nations (2023), the United Nations Population Division (2023), and the World Bank (2023a, 2023b). Quantitative analysis techniques are applied to analyze the short- and long-term effects of fertility rates, population aging, healthcare expenditure, inflation, and interest rates on Japan's economic growth.

The study employs Stationarity Tests and Cointegration Tests to ensure model validity and assess the relationship between demographic and macroeconomic variables. The Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test are used to detect unit roots in the time-series data (Li et al., 2024). If the data is found to be non-stationary, it is differenced until stationarity is achieved. Additionally, the study accounts for structural breaks, such as the 1990s Japanese economic crisis and the 2008 global financial crisis, to improve the robustness of the analysis.

Once stationarity is confirmed, the Johansen Cointegration Test is applied to determine long-run relationships among key variables, including fertility rates, population aging, healthcare expenditure, inflation, interest rates, and economic growth.

The Trace Statistic and Maximum Eigenvalue Statistic are used to confirm the presence of long-term equilibrium relationships despite short-term fluctuations.

Given the dynamic nature of these relationships, the Vector Error Correction Model (VECM) is employed as the primary analytical tool. The VECM approach is particularly suitable for capturing short-run fluctuations while maintaining the consistency of long-term relationships. This method provides a comprehensive analysis of the intricate interactions between demographic and macroeconomic variables, ensuring the accuracy of the results and their relevance for policy formulation.

The VECM regression model used in this study is as follows (Enders, 2014):

$$\Delta Y_t = A_0 + \sum_{i=1}^{n} \Delta Y_{t-i} + \gamma_1 ECT_{t-i} + \varepsilon_t \quad \ldots\ldots (1)$$

The autoregressive technique is utilized to estimate the future values of a given variable (Y_t), which is assumed to be linearly dependent on its past values (Y_{t-1}). The model specifications for the key variables are as follows:

$$\Delta PE_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta PE_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PP_{t-i} + \sum_{i=1}^{m} \alpha_3 \Delta PK_{t-i} + \sum_{i=1}^{m} \alpha_4 \Delta SB_{t-i} + \sum_{i=1}^{m} \alpha_5 \Delta IHK_{t-i} + \alpha_6 ECT1_{t-i} + \varepsilon_{1t} \quad \ldots\ldots (2)$$

$$\Delta PP_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta PP_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PE_{t-i} + \sum_{i=1}^{m} \alpha_3 \Delta PK_{t-i} + \sum_{i=1}^{m} \alpha_4 \Delta SB_{t-i} + \sum_{i=1}^{m} \alpha_5 \Delta IHK_{t-i} + \alpha_6 ECT1_{t-i} + \varepsilon_{1t} \quad \ldots\ldots (3)$$

$$\Delta PK_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta PK_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PE_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PP_{t-i} + \sum_{i=1}^{m} \alpha_4 \Delta SB_{t-i} + \sum_{i=1}^{m} \alpha_5 \Delta INF_{t-i} + \alpha_6 ECT1_{t-i} + \varepsilon_{1t} \quad \ldots\ldots (4)$$

$$\Delta SB_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta SB_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PE_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PP_{t-i} + \sum_{i=1}^{m} \alpha_4 \Delta PK_{t-i} + \sum_{i=1}^{m} \alpha_5 \Delta IHK_{t-i} + \alpha_6 ECT1_{t-i} + \varepsilon_{1t} \quad \ldots\ldots (5)$$

$$\Delta IHK_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta IHK_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PE_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta PP_{t-i} + \sum_{i=1}^{m} \alpha_4 \Delta PK_{t-i} + \sum_{i=1}^{m} \alpha_5 \Delta SB_{t-i} + \alpha_6 ECT1_{t-i} + \varepsilon_{1t} \quad \ldots\ldots (6)$$

RESULTS AND DISCUSSION

Japan's economic growth faces significant challenges due to persistently low fertility rates and a rising elderly population, both of which impact productivity and increase fiscal burdens. Conversely, factors such as healthcare spending, moderate inflation, and low interest rates play a crucial role in supporting sustainable economic growth. Table 1 presents a statistical summary of each variable, including the mean, median, maximum and minimum values, and standard deviation, providing deeper insight into data variations over the study period.

Table 1. Statistic descriptive

Variable	Mean	Median	Maximum	Minimum	Standard Deviation
Economic growth (PE)	3.48017	2.79112	12.88247	-5.69324	3.94588
Fertility Rate (TFR)	1.62781	1.51500	2.23000	1.20000	0.30022
Population Aging (PP)	15.41831	13.15523	30.06763	5.79927	8.01903
Health Expenditure (PK)	5.92283	5.46100	11.00000	2.00200	2.99554
Interest Rate (SB)	3.08688	2.52083	9.00000	0.10000	2.79629
Inflation (INF)	2.93365	1.83000	23.22225	-1.35284	4.02675

Source: The International Monetary Fund (2023a, 2023b), the United Nations (2023), the United Nations Population Division (2023), and the World Bank (2023a, 2023b).Processed data, 2024

Table 1 provides a descriptive analysis of the key variables affecting Japan's economic growth from 1960 to 2023. The economic growth rate (PE) has an average of 3.48%, with a median of 2.79%, suggesting that most years experienced moderate growth. However, the large fluctuations, ranging from a maximum of 12.88% to a minimum of -

5.69%, indicate significant periods of economic expansion and contraction, including recessions.

The fertility rate (TFR) averages 1.63, with a median of 1.51, reflecting a persistent decline in birth rates well below the replacement level of 2.1. The low standard deviation (0.30) indicates relative stability in this downward trend.

Meanwhile, population aging (PP) has a mean of 15.42%, with a standard deviation of 8.02, highlighting a substantial increase in Japan's elderly population over time. The maximum value of 30.06% underscores the growing demographic burden on the economy in certain years.

Healthcare expenditure (PK) shows an average of 5.92% and a median of 5.46%, with a maximum value of 11.00%, indicating a significant investment in human capital, particularly to support the aging population. The standard deviation of 2.99 reflects considerable variation in healthcare spending over the years.

Regarding monetary policy, the interest rate (SB) has an average of 3.09%, with a minimum of 0.10% and a maximum of 9.00%. This reflects Japan's adoption of a low-interest rate policy in recent decades to encourage investment and consumption. The standard deviation of 2.80 suggests notable fluctuations in interest rates over the study period.

Lastly, inflation (INF) has an average rate of 2.93%, with a median of 1.83%, indicating a relatively moderate inflationary trend. However, the high variability—ranging from -1.35% (deflation) to 23.22% (high inflation)—demonstrates significant economic instability during certain periods. The standard deviation of 4.03 further reflects substantial fluctuations in inflation rates over time.

Overall, this statistical analysis demonstrates that demographic variables—such as the fertility rate and population aging—along with macroeconomic factors—such as healthcare spending, interest rates, and inflation—significantly influence Japan's economic performance. These findings provide a strong foundation for understanding the dynamics of the Japanese economy and their implications for future economic policies.

The first stage of the analysis involves conducting a unit root test to determine whether a time series exhibits a unit root, which would indicate that the series is non-stationary and follows a stochastic trend. The presence of a unit root suggests that any shock to the time series will have long-term effects.

Table 2. Unit root test results

Level		First Difference		Second Difference	
Series	Prob.	Series	Prob.	Series	Prob.
PE	0.3022	D(PE)	0.00	D(PE,2)	0.00
TFR	0.8682	D(TFR)	0.00	D(TFR,2)	0.00
PP	0.4732	D(PP)	0.58	D(PP,2)	0.00
PK	0.9899	D(PK)	0.01	D(PK,2)	0.00
SB	0.731	D(SB)	0.00	D(SB,2)	0.00
INF	0.0748	D(INF)	0.00	D(INF,2)	0.00

The unit root test results provide insights into the stationarity properties of key economic variables in Japan, including economic growth (PE), fertility rate (TFR), population aging (PP), health expenditure (PK), interest rates (SB), and inflation (INF).

For economic growth (PE), the probability value at the level is 0.3022, indicating that the variable is non-stationary, meaning that it exhibits a trend or pattern that changes over time. However, after first differencing, the probability drops to 0.00, indicating that PE becomes stationary, meaning that long-term trends no longer influence changes in

economic growth from one period to the next.

Table 3. Cointegration test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.**
PE	0.942774	395.6042	95.75366	0.0001
TFR	0.870711	232.5416	69.81889	0.0000
PP	0.707202	115.9365	47.85613	0.0000
PK	0.366066	45.92492	29.79707	0.0003
SB	0.238209	19.94373	15.49471	0.0100
INF	0.074857	4.434979	3.841466	0.0352
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.
PE	0.942774	163.0626	40.07757	0.0001
TFR	0.870711	116.6050	33.87687	0.0000
PP	0.707202	70.01162	27.58434	0.0000
PK	0.366066	25.98118	21.13162	0.0096
SB	0.238209	15.50876	14.26460	0.0316
INF	0.074857	4.434979	3.841466	0.0352

The results of the cointegration test indicate that all analyzed variables exhibit at least one long-run relationship, as confirmed by both the Trace Test and the Maximum Eigenvalue Test. The low probability values ($p < 0.05$) in both tests lead to the rejection of the null hypothesis of no cointegration, suggesting that these variables tend to move together over time.

This analysis reveals that in Japan, population aging (PP) and interest rates (SB) have a significant negative effect on long-term economic growth. In contrast, health expenditure (PK) and inflation (INF) contribute positively. The fertility rate (TFR), however, does not exhibit a significant long-term relationship with economic growth.

In the short-term adjustment process, population aging (PP) and health expenditure (PK) play crucial roles, while interest rates (SB) and inflation (INF) do not demonstrate significant short-term effects. The fertility rate (TFR) has some impact on short-run adjustments, though its effect remains relatively weak. Understanding these short- and long-term dynamics is essential for formulating effective economic policies, particularly in addressing Japan's aging population and ensuring sustainable economic growth.

Table 4. Cointegration coefficient and error correction

Variables	Cointegration Coefficient	Cointegration t-Statistic	Error Correction Coefficient	t-Statistic Error Correction
TFR	-6485.44	-1.21922^{x}	0.000217	1.99709***
PP	-4681.1	-5.8355***	-1.21E-05	-3.66987***
PK	11193.57	5.49321***	4.41E-06	2.27537***
SB	-4374.03	-5.5167***	-7.28E-06	-1.09586^{x}
INF	1302.072	4.37126**	4.64E-05	1.36132^{x}

x = not significant

****, **, * indicate significance levels of 1%, 5%, and 10%, respectively*

The results in Table 4 further confirm that in Japan, population aging (PP) and interest rates (SB) exert a significant negative effect on long-term economic growth, while

health expenditure (PK) and inflation (INF) positively contribute to growth. The fertility rate (TFR) does not show a significant long-term relationship with economic growth.

In the short-term adjustment process, population aging (PP) and health expenditure (PK) are key factors, whereas interest rates (SB) and inflation (INF) do not exhibit significant short-term effects. The fertility rate (TFR) has some influence in the short term, though its impact remains limited.

These findings emphasize the critical role of healthcare investment and demographic management in sustaining Japan's economic growth. Policymakers should focus on mitigating the economic burden of an aging population while leveraging health expenditure and inflation control to maintain long-term stability.

Table 5. Short-term dynamics

Variables	Long-term Coefficient	Long-Term t-Statistic	Short Term Coefficient (Lag 1)	Short-Term t-Statistic (Lag 1)	Short Term Coefficient (Lag 2)	Short-Term t-Statistic (Lag 2)
TFR	-6485.44	-1.21922^{x}	5.897378	1.32374^{x}	3.867384	0.92632^{x}
PP	-4681.1	-5.8355***	-11.6769	-1.71826^{x}	4.696829	0.76597^{x}
PK	11193.57	5.49321***	-0.55221	-0.23192^{x}	1.664416	0.74912^{x}
SB	-4374.03	-5.5167***	0.08409	0.13862^{x}	0.185434	0.32793^{x}
INF	1302.072	4.37126***	-0.3762	-1.54995^{x}	-0.2384	-1.08152^{x}

x = not significant

****, **, * indicate significance levels of 1%, 5%, and 10%, respectively*

Overall, variables such as the fertility rate, population aging, health expenditure, interest rates, and inflation have a more pronounced influence on economic growth in the long run than in the short run. This study finds that the fertility rate does not have a significant impact on Japan's economic growth in either the short or long term. This can be attributed to the high level of automation and technological integration in the Japanese economy, which has effectively offset the impact of declining birth rates on the labor supply. Additionally, efficiency in production processes, driven by the principle of kaizen (continuous improvement), along with the strategic use of foreign labor in specific sectors, has helped mitigate the negative effects of low fertility rates. These adaptations reflect a shift in Japan's policy priorities from increasing birth rates to optimizing available resources to sustain economic performance.

In contrast, population aging has a significant negative impact on long-term economic growth. Beyond increasing the economic burden of pension and healthcare expenditures, an aging population reduces labor productivity and slows innovation. The shrinking younger workforce diminishes labor market dynamism, limiting adaptability to emerging technologies and new economic trends.

Japan has sought to address these challenges through lifelong learning policies, retraining programs for senior workers, and advancements in robotics and artificial intelligence to reduce dependence on human labor. However, despite these initiatives, structural constraints associated with population aging continue to pose significant challenges to achieving sustainable economic growth.

The study also found that inflation has a significant impact on long-term economic growth, as moderate inflation can stimulate consumption and investment. However, the effectiveness of inflation as a driver of growth depends on supporting policies, such as wage adjustments in line with price increases to maintain household purchasing power. If wages remain stagnant while prices rise, the positive effects of inflation may be

diminished. Additionally, maintaining controlled inflation through the Bank of Japan's monetary policy is crucial to ensuring that inflation remains at a level conducive to economic growth. Therefore, the success of inflation as a growth instrument requires coordinated policies that balance consumption, investment, and price stability.

These findings highlight the importance of an integrated approach to addressing Japan's demographic and macroeconomic challenges to ensure sustainable growth. A key policy trade-off in this context lies between addressing fertility decline and maintaining economic stability. Encouraging higher fertility rates would require substantial public expenditures on subsidies, childcare support, and flexible work policies, which could place additional strain on fiscal resources. Conversely, sustaining economic stability necessitates continued investment in technology and human capital to counteract the effects of demographic shifts.

Policymakers must carefully balance these competing priorities, ensuring that resources are allocated effectively to both foster long-term demographic resilience and sustain immediate economic growth.

Investment in healthcare spending, regarded as an investment in human capital, has been shown to have a significant positive impact on long-term economic growth. This aligns with human capital theory, which posits that investment in health enhances labor productivity and extends the productive lifespan of the workforce. Research by Yang (2020) supports this finding, demonstrating that health expenditure and economic growth exhibit significant interval effects due to varying levels of human capital development. In the short term, healthcare spending may not yield immediate improvements in health outcomes; however, in the long term, a healthier population contributes to more sustainable economic growth. Similarly, research by Beylik et al. (2022) reinforces this conclusion, showing that health spending enhances human capital productivity, thereby positively influencing economic growth.

Beyond healthcare investment, interest rates, and inflation also play complex roles in shaping Japan's economic performance. High interest rates significantly hinder long-term economic growth, consistent with existing research indicating that elevated interest rates suppress investment and consumption. In contrast, inflation has a significant positive long-term impact, supporting the argument that moderate inflation stimulates economic activity by encouraging consumption and investment. Research by Celik et al. (2023) suggests that health spending not only boosts labor productivity but also indirectly affects inflation and economic growth, further underscoring the intricate relationship between these factors.

Furthermore, research by Ahiadorme (2022) confirms that moderate inflation fosters economic growth, whereas excessively high or low inflation can destabilize the economy. This highlights the importance of stable and controlled inflation as a key policy objective for promoting sustainable economic growth in Japan.

This study highlights the complex interplay between demographic changes and macroeconomic factors that shape Japan's long-term economic growth. The labor force and productivity have been significantly affected by key challenges such as declining fertility rates and population aging. Despite these demographic shifts, Japan has adapted through resource optimization, leveraging automation, technological integration, and the strategic use of foreign labor to mitigate labor shortages.

At the same time, moderate inflation and healthcare expenditures have emerged as critical drivers of sustainable economic growth. However, their effectiveness depends on supporting policies, including wage adjustments and preventive healthcare initiatives.

These findings emphasize the importance of implementing targeted and integrated policy strategies to address Japan's demographic and macroeconomic challenges.

The following policy recommendations focus on optimizing existing resources, reducing fiscal pressures, and maintaining labor market dynamism, all while ensuring long-term economic stability (Table 6).

Table 6. Summarizing policy implications

Policy Focus	Recommendation	Expected Impact
Fertility Rate and Resource Optimization	Focus on optimizing resources through automation and the strategic use of foreign labor in key sectors.	Mitigate labor shortages caused by declining birth rates while maintaining productivity levels.
Addressing Population Aging	Increase the retirement age, introduce retraining programs for senior workers, and expand the use of robotics and artificial intelligence (AI).	Reduce the fiscal burden of pensions and healthcare while maintaining labor market dynamism and productivity.
Inflation Management	Align wage growth with inflation and maintain controlled inflation through stable monetary policies.	Boost consumption and investment while ensuring stable economic growth.
Health Expenditure as Human Capital Investment	Expand access to quality healthcare and promote preventive care to reduce long-term healthcare costs.	Enhance labor productivity and support long-term economic growth.
Balancing Policy Trade-Offs	Prioritize technology-driven productivity over costly fertility-boosting policies.	Maintain short-term economic stability while fostering long-term demographic resilience.
Integrated Policy Approach	Align fiscal and monetary policies with demographic strategies and increase investments in technology, education, and healthcare.	Create synergy between demographic and economic policies to ensure sustainable growth.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study highlights the significant impact of demographic factors, particularly population aging, on Japan's economic growth from 1960 to 2023. Population aging has substantially hindered long-term economic growth due to the increasing fiscal burden of healthcare expenditures and pensions. In contrast, the declining fertility rate has shown an insignificant negative impact on economic performance. Healthcare spending has contributed positively to long-term economic growth by enhancing human capital, although its short-term effects remain negative. Additionally, high interest rates have constrained economic expansion in the long run, while moderate inflation has supported economic growth by stimulating consumption and investment.

Recommendations

Comprehensive policy reforms are needed to address the challenges posed by population aging. Reforming the pension system by gradually increasing the retirement age, linking pension benefits to life expectancy, and encouraging individual retirement savings can help alleviate the fiscal burden. Policies should also focus on integrating older workers into the labor market by introducing flexible working arrangements, retraining

programs, and incentives for companies to employ senior workers. Providing tax incentives or subsidies to businesses that invest in ergonomics and age-friendly technologies can further facilitate the participation of older workers.

Technological innovation plays a crucial role in mitigating labor shortages and supporting economic growth despite demographic challenges. Expanding the use of automation and artificial intelligence, particularly in manufacturing, healthcare, and aged care, can enhance productivity where labor demand is highest. Robotics can help bridge labor gaps in aged care, reducing the economic strain of an aging population. Digital transformation in the workplace can also enable elderly workers to remain productive by minimizing physical demands.

Creating an environment that fosters technological advancement is essential. Increasing research and development funding, implementing technology-friendly regulations, and strengthening collaboration between the public and private sectors can drive innovation and economic resilience. When combined with sound fiscal and monetary policies, these measures will help Japan turn demographic challenges into opportunities for long-term economic sustainability.

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