The Relationship Between Aging, Economic Development and Healthcare Expenditure in Japan: An Empirical Analysis

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Abstract. This paper investigates the relationship between ageing, economic development, and healthcare expenditure in Japan, considering the challenges posed by an ageing population. The study utilizes a VAR and ARMAX modelling approach to analyse the complex dynamics among these variables. The empirical results reveal interesting findings that contrast with previous literature. While population ageing is often assumed to lead to increased healthcare spending, this study finds no significant correlation between population ageing and healthcare expenditure as a percentage of GDP. The analysis suggests that factors such as advancements in medical technology, healthcare system efficiency, and cultural variations in healthcare utilization patterns may have mitigated the expected rise in healthcare expenditure associated with an ageing population. These findings have implications for policymakers and investors. Policymakers should consider a broader range of factors beyond population ageing when projecting future healthcare expenditures and developing strategies for managing healthcare costs. Investors can benefit from a nuanced understanding of the healthcare sector, focusing on areas such as medical technology, innovation, and healthcare delivery models that are likely to be influenced by population ageing and changing healthcare needs. Overall, this research contributes to the existing knowledge base, offering insights for addressing the challenges of population ageing and healthcare sustainability.

1 Introduction

1.1 Background and Significance

The ageing population is a significant global phenomenon with profound implications for economies and healthcare systems worldwide. Japan has been experiencing a rapid demographic shift towards an ageing society. This demographic transition brings about complex challenges, including the strain on healthcare resources and potential impacts on economic development. Understanding the relationship between ageing, economic development, and healthcare expenditure is crucial for policymakers and investors to effectively address these challenges.

Japan's ageing population has been driven by a combination of declining birth rates, increased life expectancy, and advancements in healthcare. As a result, the proportion of elderly individuals in the population has steadily risen, posing unique social, economic, and healthcare-related challenges. The United Nations estimates that by 2050, approximately 37% of Japan's population will be aged 65 or older [1]. This demographic shift has far-reaching consequences, including a shrinking workforce, increased dependency ratios, and changes in consumption patterns.

One of the key concerns associated with an ageing population is the strain it places on healthcare systems. Older individuals typically require more healthcare services and have a higher prevalence of chronic diseases, so the more mainstream perception in society is that higher rates of aging will inevitably lead to increased healthcare expenditures [2]. Although Japan's healthcare system, known for its high quality and accessibility, faces significant challenges in adapting to the needs of an ageing society while ensuring the financial sustainability of healthcare financing. Balancing the provision of comprehensive healthcare services with cost containment measures becomes a delicate task for policymakers. While it is true that population aging needs to be countered with more adequate health care spending, whether there is a significant positive correlation between the two should still be illustrated by empirical evidence.

Simultaneously, economic development is crucial for sustaining a high standard of living, promoting innovation, and fostering overall societal well-being. The relationship between economic development and ageing is multifaceted. On the one hand, an ageing population can exert pressure on economic growth as a shrinking workforce may lead to a decline in productivity and a shortage of skilled labor [3]. On the other hand, some research suggests that an increase in health care coverage does not necessarily have a negative effect on economic development; rather, tilting the economy in favor of health care coverage may be beneficial in promoting economic growth [4].

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1.2 Literature Review

A comprehensive review of existing literature provides valuable insights into the relationship between ageing, economic development, and healthcare expenditure in Japan. Previous studies have examined various aspects of this relationship, employing different methodological approaches and datasets. Some research has explored the impact of ageing on economic growth, finding mixed results and highlighting the need for further investigation.

For example, while some studies suggest that population ageing negatively affects economic growth due to labor market dynamics [5], others argue that the potential for technological advancements and increased labor force participation by older individuals can offset these challenges [6].

Other studies have focused on the implications of population ageing for healthcare expenditure, recognizing the potential strain it poses on healthcare systems. The increase in healthcare spending associated with an ageing population can be attributed to factors such as higher demand for healthcare services, increased prevalence of chronic diseases, and advancements in medical technology [7]. Moreover, the allocation of healthcare resources becomes a critical concern as policymakers strive to meet the diverse needs of an ageing population while ensuring equitable access to care [8].

Moreover, several studies have investigated the interplay between economic development and healthcare expenditure in the context of an ageing population. These studies have explored how changes in economic indicators, such as GDP per capita or income inequality, influence healthcare spending and resource allocation. For instance, higher levels of economic development may lead to increased healthcare expenditure as individuals have greater purchasing power and demand for higher-quality healthcare services [9]. However, the relationship between economic development and healthcare expenditure is complex, as other factors, such as healthcare system efficiency and the effectiveness of healthcare policies, also play a role [10].

Understanding the dynamic interactions among ageing, economic development, and healthcare expenditure is crucial for devising effective policies and strategies to address the challenges posed by an ageing population. Policymakers need evidence-based insights to make informed decisions regarding healthcare resource allocation, long-term care policies, labor market reforms, and social security systems. Likewise, investors can benefit from understanding the implications of population ageing on various sectors, such as healthcare, technology, and consumer goods.

A comprehensive review of existing literature on the relationship between ageing, economic development, and healthcare expenditure reveals mixed findings. Some studies suggest that population ageing negatively affects economic growth due to labor market dynamics, while others argue that technological advancements and increased labor force participation by older individuals can offset these challenges. Similarly, the relationship between economic development and healthcare expenditure is complex, with some studies indicating a positive correlation, while others emphasize the role of healthcare system efficiency and policies. Understanding these dynamics is crucial for policymakers and investors to address the challenges of population ageing. Despite the existing body of literature, there is a need for a comprehensive analysis that incorporates both economic and healthcare factors, accounting for the complex dynamics between them. This paper aims to bridge this gap by utilizing a VAR and ARMAX modeling approach to explore the relationship between ageing, economic development, and healthcare expenditure in Japan. By providing empirical evidence and in-depth analysis, this research contributes to the existing knowledge base, offering insights for policymakers and investors in addressing the challenges of population ageing and healthcare sustainability.

In the following sections, this paper presents the research design, empirical results, and analysis, followed by a discussion of the findings in relation to the existing literature. Additionally, the implications of this research for policymakers, investors, and the broader society are explored. The paper concludes by summarizing the main findings and highlighting avenues for future research.

2 Research Design

2.1 Data Sources

To investigate the relationship between ageing, economic development, and healthcare expenditure in Japan, this study utilizes a combination of population, macroeconomic and healthcare data, which refer specifically to the aging rate, GDP, and healthcare expenditure as a percentage of GDP. These data are obtained from World Bank [11] and Organisation for Economic Cooperation and Development [12]. Healthcare expenditure data, which captures the financial resources allocated to healthcare services, are essential for understanding the impact of population ageing on the healthcare system.

2.2 Weak Stationarity Test

Before proceeding with the modeling, this paper first considered the stationarity of the variables, which means that the statistical properties of the variables remain constant over time. In this paper, the unit root test is used to test the GDP, population aging rate and healthcare expenditure as a percentage of GDP, and the results are shown in Table 1, and the results are all non-stationary. Therefore, the variables were first-order differenced and tested again. According to the growth rate in Table 1, the growth rates of GDP and healthcare expenditure as a percentage of GDP are stable, while the growth rate of population aging is still non-stationary.

Table 1 Weak Stationarity Test: ADF test

	t	p

Table 1 Weak Stationarity Test: ADF test (continues)

Raw		
GDP	-2.083	0.5557
Aging rate	-0.953	0.9502
Health expenditure	-1.697	0.7523
Growth rate		
GDP	-4.985	0.0002***
Aging rate	-2.815	0.1916
Health expenditure	-3.775	0.0179**

2.3 VAR Model Setting

To examine the dynamic relationship between the share of elderly population, GDP, and the share of health expenditure in GDP, this paper first attempts to test the variables using the vector autoregressive (VAR) model that allows for the analysis of multiple variables simultaneously and captures their interdependence over time. In this study, the following model was constructed with the first-order differences of the variables to ensure stationary:

$$GDP_t = \alpha_{GDP,0} + \alpha_{GDP,1}GDP_{t-1} + \cdots + \alpha_{GDP,p}GDP_{t-p} + \beta_{GDP,1}AR_{t-1} + \cdots + \beta_{GDP,p}AR_{t-p} + \gamma_{GDP,1}HE_{t-1} + \cdots + \gamma_{GDP,p}HE_{t-p} + \varepsilon_{GDP,t} \quad (1)$$

$$AR_t = \alpha_{AR,0} + \alpha_{AR,1}GDP_{t-1} + \cdots + \alpha_{AR,p}GDP_{t-p} + \beta_{AR,1}AR_{t-1} + \cdots + \beta_{AR,p}AR_{t-p} + \gamma_{AR,1}HE_{t-1} + \cdots + \gamma_{AR,p}HE_{t-p} + \varepsilon_{AR,t} \quad (2)$$

$$HE_t = \alpha_{HE,0} + \alpha_{HE,1}GDP_{t-1} + \cdots + \alpha_{HE,p}GDP_{t-p} + \beta_{HE,1}AR_{t-1} + \cdots + \beta_{HE,p}AR_{t-p} + \gamma_{HE,1}HE_{t-1} + \cdots + \gamma_{HE,p}HE_{t-p} + \varepsilon_{HE,t} \quad (3)$$

In Equation (1), the growth rate of GDP (GDP_t) is influenced by its own lagged values (GDP_{t-1} to GDP_{t-p}), as well as the lagged values of population aging (AR_{t-1} to AR_{t-p}) and health care expenditure (HE_{t-1} to HE_{t-p}). The coefficients α_{GDP}, β_{GDP}, and γ_{GDP} represent the impact of the lagged values of GDP, population aging, and health care expenditure, respectively, on the current GDP growth rate. The term ε_{GDP} represents the error or unexplained variation in the GDP equation.

Equation (2) represents the growth rate of population aging (AR_t), which is influenced by its own lagged values, as well as the lagged values of GDP and health care expenditure. The coefficients α_{AR}, β_{AR}, and γ_{AR} capture the impact of the lagged variables on the current population aging growth rate, while ε_{AR} represents the error term in this equation.

Similarly, Equation (3) represents the growth rate of health care expenditure (HE_t), which is affected by its own lagged values, as well as the lagged values of GDP and population aging. The coefficients α_{HE}, β_{HE}, and γ_{HE} reflect the impact of the lagged variables on the current health care expenditure growth rate, and ε_{HE} represents the error term in this equation.

2.4 ARMAX Model Specification

In addition, to account for potential exogenous influences on the system, an autoregressive moving average with exogenous inputs (ARMAX) model is also employed in this paper. The ARMAX model extends the VAR framework by including additional external factors that may affect the variables of interest. These exogenous variables can capture policy interventions, technological advancements, or other factors that impact economic development and healthcare expenditure but are not endogenously determined by the system. Thus, the ARMAX model allows for a more comprehensive analysis of the relationship between ageing, economic development, and healthcare expenditure by considering the potential influence of external factors on the observed dynamics.

$$GDP_t = \varphi_0 + \varphi_1 GDP_{t-1} + \cdots + \varphi_p GDP_{t-p} + a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q} + \gamma_1 AR_{t-1} + \cdots + \gamma_{q1} AR_{t-q1} \quad (4)$$

$$HE_t = \varphi_0 + \varphi_1 HE_{t-1} + \cdots + \varphi_p HE_{t-p} + a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q} + \gamma_1 AR_{t-1} + \cdots + \gamma_{q1} AR_{t-q1} \quad (5)$$

Equation (1) represents the growth rate of GDP (GDP_t) and includes autoregressive terms ($\varphi_1 GDP_{t-1} + \cdots + \varphi_p GDP_{t-p}$) capturing the influence of its own lagged values. The term at represents the white noise or error component in the GDP equation. Additionally, the model incorporates the growth rate of population aging (AR_t) as an exogenous input, with coefficients ($\gamma_1 AR_{t-1} + \cdots + \gamma_{q1} AR_{t-q1}$). This allows for examining the relationship between GDP growth and population aging, considering the impact of population aging on GDP growth over time.

Equation (2) represents the growth rate of health care expenditure as a percentage of GDP (HE_t) and follows a similar structure as Equation (1). It includes autoregressive terms ($\varphi_1 HE_{t-1} + \cdots + \varphi_p HE_{t-p}$) capturing the influence of its own lagged values and an error term (a_t). The model also incorporates the growth rate of population aging (AR_t) as an exogenous input, with coefficients ($\gamma_1 AR_{t-1} + \cdots + \gamma_{q1} AR_{t-q1}$). This allows for examining the relationship between GDP growth and health care expenditure as a percentage of GDP, considering the impact of population aging on health care expenditure.

By incorporating both the VAR and ARMAX modeling approaches, this research design provides a robust framework for analyzing the complex interplay between ageing, economic development, and healthcare expenditure in Japan. It allows for the exploration of dynamic relationships, the identification of key drivers, and the assessment of the impact of exogenous factors on the system. This approach enhances the understanding of the long-term implications of population ageing on the economy and healthcare system and facilitates evidence-based decision-making for policymakers and investors.

3 Empirical Results and Analysis

3.1 VAR Fixed-Order and Stability Tests

Before proceeding with the analysis of the VAR model, it is essential to determine the appropriate lag order to capture the dynamics of the variables adequately. The selection of the lag order can be informed by various criteria. In this paper, several commonly used criteria for fixing the order of VAR models are selected and the results of each criterion are considered together to determine the order of the model. By comparing the values of these criteria for different lag orders, we can identify the lag order that minimizes information loss while avoiding overfitting. The order fixing criteria used are: the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), or the Hannan-Quinn Information Criterion (HQIC), and the final forecast error criterion (FPE). As shown in Table 2, after fixing the order of the first-order differences of the variables, the 11th-order lag term is selected in this paper based on the judgment of the majority information criterion.

Table 2 Likelihood ratio test and information criterion

Lag	LL	LR	p	FPE	AIC	HQIC	SBIC
0	244.204			6.2e-10	-12.6949	-12.649	-12.5657
1	275.706	63.003	0.000	1.9e-10	-13.8792	-13.6953	-13.3621
2	294.161	36.911	0.000	1.2e-10	-14.3769	-14.0549	-13.4719
3	304.843	21.364	0.011	1.1e-10	-14.4654	-14.0055	-13.1726
4	318.547	27.408	0.001	8.9e-11	-14.713	-14.115	-13.0323
5	323.379	9.663	0.378	1.2e-10	-14.4936	-13.7577	-12.4251
6	328.101	9.4435	0.397	1.7e-10	-14.2685	-13.3945	-11.8121
7	333.133	10.064	0.345	2.6e-10	-14.0596	-13.0477	-11.2154
8	350.27	34.274	0.000	2.3e-10	-14.4879	-13.3379	-11.2558
9	386.906	73.274	0.000	8.3e-11	-15.9424	-14.6545	-12.3225
10	409.269	44.724	0.000	8.5e-11	-16.6457	-15.2198	-12.6379
11	462.838	107.14*	0.000	3.1e-11	-18.9915*	-17.4276*	-14.5959*
12				-1.2e-43*			

Once the appropriate lag order is determined, stability tests are conducted to ensure that the VAR model does not suffer from explosive or explosive roots. Stability is crucial for reliable estimation and forecasting. However, the characteristic roots in Figure 1 are not perfectly distributed within the unit circle. Therefore, the VAR model is considered non-stationary. Based on this finding, this paper uses the ARMAX model instead to analyze the growth rates of the three data.

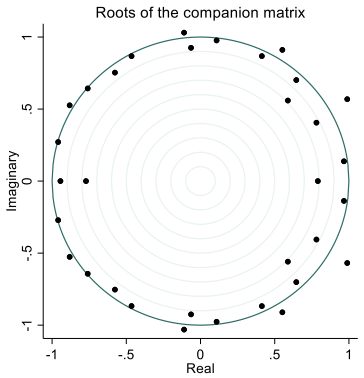

Fig. 1. Unit root test

Photo credit: Original

3.2 ARMA Order Identification

Incorporating the ARMAX framework, it is necessary to determine the appropriate orders of the autoregressive moving average (ARMA) component. The ARMA order fixation is accomplished through model diagnostics, including the examination of autocorrelation and partial autocorrelation functions, residual analysis, and information criteria. These diagnostics provide insights into the appropriate ARMA orders that capture the serial correlation and the noise structure adequately.

PACF ACF

GDP growth rate

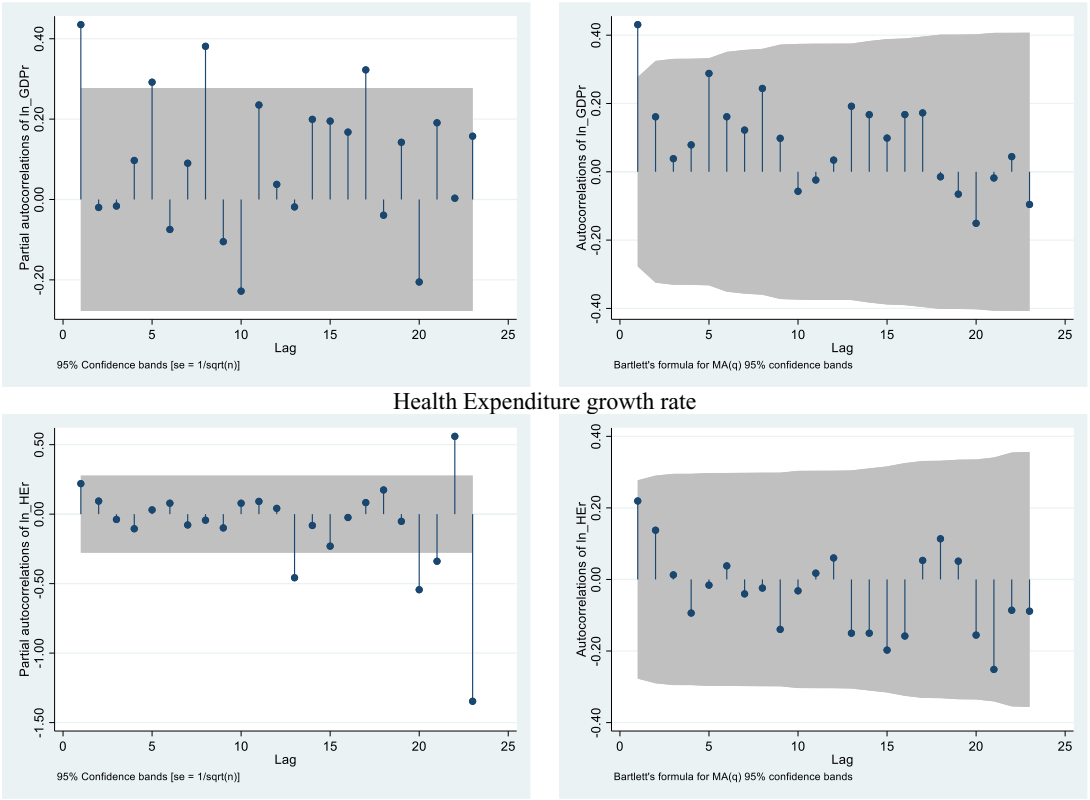

Fig. 2. ARMA (p, q) identification

Photo credit: Original

In this paper, by plotting the Figure 2 ARMA (p, q) identification, we judge that both variables have first-order truncated tails of ACF and first-order truncated tails of PACF, so we choose to use ARMA (1, 1) model to fit them in this paper.

Table 3 ARMAX regression results: GDP growth rate as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)
AR, L1	-0.36	3.73	3.67	3.44	-0.12	-1.93
	0.720	0.00	0.00	0.001	0.904	0.054
MA, L1	0.73	-0.00	-0.00	-0.00	0.27	2.39
	0.463	1.00	1.00	1.00	0.791	0.017
Constant	5.22	12.49	11.79	9.81	4.57	5.43
	0.000	0.00	0.00	0.000	0.000	0.000
Aging rate						
D1	-3.78	-1.29	-1.84	-0.36	-0.85	-0.57
	0.000	0.198	0.066	0.717	0.393	0.569
LD		-0.20	0.63	-0.35	0.13	-0.10
		0.840	0.527	0.727	0.898	0.924
L2D			-0.69	0.56	-0.02	0.21
			0.488	0.578	0.982	0.831
L3D				-0.98	0.16	-0.20
				0.325	0.875	0.844
L4D					-0.51	0.21
					0.610	0.830
L5D						-0.48
						0.631

In addition, to investigate the effect of aging growth rate on the growth rate of the above two variables, this paper refines the ARMA model to ARMAX model and add the current aging growth rate and its lagged term to it. According to the regression results of Table 3, the effect of aging growth rate on the growth rate of the other two variables is not significant, and even the current aging rate does not have a significant effect on the growth rate of health care expenditure as a percentage of GDP, but the effect of aging growth rate on GDP growth rate is very significant, and the correlation coefficient is negative, with -3.78.

Table 3 ARMAX regression results: health expenditure growth rate as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)
Table 3 ARMAX regression results: health expenditure growth rate as dependent variable (continues)						
AR, L13	-1.35	-1.21	-1.20	-1.19	-1.56	-1.50
	0.177	0.226	0.229	0.235	0.118	0.134
Constant	1.02	1.23	1.01	0.83	1.31	0.83
	0.307	0.220	0.311	0.407	0.189	0.405
Aging rate						
D1	0.31	-0.60	-0.22	0.04	0.50	0.61
	0.760	0.548	0.825	0.967	0.616	0.539
LD		0.61	0.13	-0.19	-0.81	-1.00
		0.545	0.900	0.851	0.420	0.319
L2D			-0.02	0.33	1.03	1.39
			0.984	0.744	0.302	0.164
L3D				-0.37	-1.12	-1.44
				0.711	0.263	0.149
L4D					1.09	1.23
					0.275	0.220
L5D						-0.97
						0.330

3.3 Estimation Results and Analysis

The estimation results of the VAR and ARMAX models provide insights into the dynamic relationship between ageing, economic development, and healthcare expenditure in Japan. By examining the coefficients, significance levels, and direction of the relationships, we can gain a better understanding of the interplay among these variables.

The estimation results of the VAR model indicate that the growth rates of the variables are still non-stationary, indicating that the VAR model does not explain the relationship between the growth rates better.

Based on the estimation results of the ARMAX model, this paper finds that the growth rate of GDP is negatively influenced by the growth rate of the aging population. This suggests that the economic growth rate will slow down as the proportion of elderly people in the population increases. The coefficient -0.3498 indicates that every 1% increase in the growth rate of the aging population leads to a 0.3498% decrease in the growth rate of GDP. This finding has similar conclusions to previous studies that have highlighted the potential challenges of an aging population on economic development.

Furthermore, the ARMAX model results also reveal that the current growth rate of the ageing population does not have a significant effect n the growth rate of healthcare expenditure as a percentage of GDP at lags less than or equal to 5. This finding contradicts the common assumption that population ageing inevitably leads to increased healthcare spending. It suggests that other factors, such as advancements in medical technology and healthcare system efficiency, may have mitigated the anticipated rise in healthcare expenditure associated with an ageing population.

The lack of a significant relationship between the growth rate of the ageing population and the growth rate of healthcare expenditure as a percentage of GDP warrants further investigation. It raises questions about the underlying drivers of healthcare spending and emphasizes the need to consider a broader range of factors beyond population ageing when projecting future healthcare expenditures. Government policies, healthcare system design, and cultural variations in healthcare utilization patterns may play vital roles in shaping healthcare spending patterns.

4 Discussion

4.1 Comparison with Existing Literature

The findings of this paper reveal an interesting contrast with the existing literature on the relationship between population aging, GDP, and health care spending. Previous studies have often suggested that as populations age, there is a significant increase in health care spending as a percentage of GDP. This is based on the assumption that an aging population would require more medical services and care. However, our analysis indicates that there is no strong correlation between population aging and health care spending as a percentage of GDP.

One possible explanation for this discrepancy could be the advancements in medical technology and improved efficiency in healthcare delivery. These factors may have mitigated the anticipated increase in healthcare expenditure associated with an aging population. Additionally, other factors such as government policies, healthcare system design, and cultural differences in healthcare utilization patterns might play a crucial role in shaping the relationship between population aging, GDP, and healthcare expenditure.

4.2 Research Implications

The research implications of this paper highlight the need for a comprehensive understanding of the complex factors influencing healthcare expenditure in the context of population aging. Future studies should delve deeper into the specific drivers of healthcare costs and explore

how different healthcare systems and policies affect spending patterns.

4.3 Understanding by Policymakers

The findings of this paper can provide valuable insights for policymakers. It suggests that policymakers should not solely rely on population aging as the primary driver for projecting future healthcare spending. Instead, they should consider a broader range of factors, such as technological advancements, healthcare system efficiency, and cultural variations in healthcare utilization. This nuanced understanding can help policymakers develop more effective strategies for managing healthcare expenditures in the face of population aging. This will be beneficial for improving the practical application of research findings.

4.4 Application by Investors

Investors can benefit from the findings of this paper by gaining a more nuanced understanding of the healthcare sector. While population aging may not directly translate into increased healthcare expenditure as a percentage of GDP, there are still investment opportunities within the healthcare industry. Investors should focus on areas such as medical technology, innovation, and healthcare delivery models that are likely to be influenced by population aging and changing healthcare needs. It aligns research findings with potential investment opportunities.

In summary, these recommendations serve to enhance the paper's academic rigor, practical relevance, and applicability for policymakers, researchers, and investors interested in the complex interplay between aging, economic development, and healthcare expenditure.

5 Conclusion

The paper focuses on examining the relationship between population aging, economic development, and healthcare expenditure in Japan. It acknowledges the challenges posed by an aging population on healthcare systems and the potential impacts on economic growth. The study aims to provide empirical evidence and insights for policymakers and investors by analyzing the dynamic interactions among these factors and emphasizing the need to consider various factors beyond population aging when addressing healthcare sustainability.

In conclusion, this paper this paper has examined the relationship between ageing, economic development, and healthcare expenditure in Japan through the utilization of VAR and ARMAX modeling approaches and finds no strong correlation between population aging and healthcare expenditure as a percentage of GDP. This contrasts with the existing literature, which has often suggested a positive relationship between population aging and healthcare expenditure. The results highlight the importance of considering other factors, such as advancements in medical technology, healthcare system efficiency, and cultural variations, in shaping healthcare spending patterns. Policymakers should take into account these multifaceted factors when formulating strategies for managing healthcare expenditures. Additionally, investors should consider the potential investment opportunities in the healthcare sector, focusing on areas influenced by population aging and evolving healthcare needs. By understanding the complexities underlying healthcare spending, policymakers and investors can make informed decisions and contribute to the sustainable provision of healthcare services in the context of population aging.

Shortcomings of this paper include the limitation of focusing solely on the relationship between population aging, GDP, and healthcare expenditure in Japan. Consider including a comparative analysis with other countries. While the focus is on Japan, it would be valuable to assess whether the relationships observed in this study hold true in different global contexts. Explore countries with varying healthcare systems and economic situations. This comparative analysis could provide insights into how different policy approaches and economic structures influence the relationship between aging, economic development, and healthcare expenditure.

While the paper relies heavily on quantitative modeling, integrating qualitative insights or case studies could offer a more holistic understanding of the factors influencing healthcare expenditure. Qualitative research could help identify specific policies or cultural practices that play a significant role in mitigating the impact of population aging on healthcare costs. It could also shed light on the experiences of healthcare providers and patients in an aging society.

Further explore and discuss the potential long-term effects of population aging on various aspects of the healthcare system. Investigate how an aging population might impact the healthcare workforce, including the supply of healthcare professionals and the demand for specific healthcare services. Consider the role of technology and innovation in adapting to the changing healthcare needs of an aging population. Explore how technology integration may affect the cost and quality of healthcare services.

By addressing these suggestions, the paper can be further refined, providing a more comprehensive and impactful contribution to the field of aging, economic development, and healthcare expenditure. It will enhance its relevance for policymakers, investors, and researchers seeking to understand and address the challenges associated with aging populations.

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