Economic Implications of Aging Populations: A Multiple Regression Analysis of GDP in Shanghai and Beijing with Policy Recommendations

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***Abstract*—An increasing body of research has begun to focus on the potential impact of an aging population on economic development, particularly in China. This country has experienced rapid economic growth due to its demographic dividend. Given this context, studying aging demographics in China has acquired a sense of urgency. This paper examines the implications of an aging population on China's economy by analyzing data from 2011 to 2021 concerning GDP, aging population, public budgets, and large enterprise expenditures in Shanghai and Beijing. Utilizing multiple regression analysis, we find that in these two economically vibrant cities, an increase in the elderly population has a positive impact on GDP. We offer plausible explanations for this phenomenon and propose several practical solutions to address China's aging population challenges. These findings not only provide valuable guidance for policymakers but also offer a new perspective on understanding the complex interplay between aging demographics and economic development.**

***Keywords*—aging population, economic development, multiple regression analysis, policy recommendations**

I. Introduction

The aging population has become a crucial topic of concern globally and particularly in China. As fertility rates decline and life expectancy increases, the proportion of elderly individuals in the population is soaring. This demographic shift has profound implications for economic performance, labor supply, social welfare policies, and the overall health of the national economy.

According to recent data from State Statistics, the percentage of the population aged between 15 and 64 has declined by 5.9% over the last decade, dropping from 74.5% in 2010 to a lesser percentage in recent years. Conversely, the share of individuals aged 65 and older has risen from 8.9% in 2010 to 13.5% in 2020. It said that this trend suggests that China is increasingly becoming an aging society, raising concerns about the sustainability of its demographic dividend, traditionally bolstered by a youthful, low-cost labor force (Zhang *et al.*, 2021).

To mitigate the adverse effects of an aging population, the Chinese government has introduced several policy measures, such as relaxing birth control policies and raising the retirement age. Despite these efforts, scholars like Zhang *et al.* (2021) argue that the aging population will inevitably erode the demographic dividend, impacting China's status as an export superpower reliant on cheap labor. Additionally, experts highlight the need to adapt and adjust the economic and employment structures, as the aged population can be both an impediment and a catalyst for industrial evolution.

The issue of aging also substantially influences the national saving ratio. While China's saving ratio currently stands at an extraordinary 45%—almost double that of other countries—it is unclear how an aging population will affect this dynamic. Empirical studies present conflicting views. For instance, research by Zhang *et al.* (2019) shows that an increase in life expectancy by one year could lead to a 3.7% increase in the saving ratio. Contrarily, other studies suggest that increased savings among the elderly could correspond with decreased saving rates among younger adults.

Japan serves as a cautionary tale, grappling with severe challenges posed by an aging population. With pension replacement rates projected to decline, the financial security of retirees is at risk, leading to reduced consumption and economic stagnation.

This paper focuses on the implications of an aging population in China's first-tier cities, which serve as the country's economic, political, and cultural hubs. Current data indicates that these cities, including Shanghai, Beijing, and Guangzhou, have a disproportionately aging population, especially when accounting for the presence of younger, non-resident workers (Tang, 2012). This demographic composition exerts additional pressure on social welfare systems and calls for targeted elderly-care policies (Yang, 2022).

Utilizing multi-regression models, this study aims to contribute to the literature by providing an in-depth examination of how the aging population affects economic metrics, labor supply, and social structures in China's first-tier cities. Specifically, we address the challenges and opportunities presented by demographic changes, while offering policy recommendations to navigate this complex landscape.

The rest of this paper is organized as follows. In Section II, this paper presents the prior studies about the aging population numbers with GDP, public budget, and industrial payment. In Section III, this paper displays the trend of these four variables and describes the trend. In sections IV and V, this paper illustrates the results of multi-regression models and discussion. In Section VI, the conclusion is given.

II. Related Work

A. Aging Population with GDP

The relationship between Gross Domestic Product (GDP) and an aging population is a topic of considerable debate, and scholarly research presents a nuanced view. Mamun's study employs the endogenous growth model to explore this relationship and presents an optimistic viewpoint. According to Mamun, an aging population is not necessarily a detriment

to GDP growth. He finds a positive relationship between an aging population and GDP in certain contexts. He argues that in countries where the birth rate is high enough to cover the aging population, the impact on the economy may even be favorable. This insight is particularly relevant for developing countries with younger populations where the challenges associated with an aging populace might not be as pertinent (Mamun *et al.*, 2020). However, Mafauzy paints a different picture, focusing on the increased healthcare costs that accompany an aging population. He observes that in Malaysia, the number of aging individuals is rising, and so are their life expectancies. This demographic change, Mafauzy (2000) argues, is likely to drive up healthcare costs significantly, especially given the incidence of chronic diseases among the elderly. Furthermore, the concentration of older people in cities will necessitate advancements in urban healthcare infrastructure to mitigate future problems. Lee introduces another variable into this discussion: the role of healthcare, or 'medication', in GDP growth. According to Lee, the growth in healthcare expenditure due to an aging population will contribute to GDP growth. However, this growth comes with a caveat—a long-term fiscal reduction, particularly evident in the post-baby boom era in the U.S. This necessitates structural changes in government plans to counterbalance the negative influences (Lee & Edwards, 2002). In contrast, Maestas underscores a more concerning trend. He reports that increased aging leads to a decrease in GDP, mainly attributed to the reduction in the labor force. This sentiment echoes older studies that often painted a bleak economic picture for countries with rapidly aging populations, citing declines in productivity and potential output (Maestas *et al.*, 2016). Lee takes the debate further by quantitatively demonstrating a negative correlation between an aging population and economic growth through linear models. Lee's research indicates that as the share of the working-age population decreases, the strain on GDP growth becomes more pronounced. Consequently, the study suggests that machines replacing human labor might be a necessary evolution to mitigate the adverse economic impacts of an aging populace (Lee & Shin, 2019). So, what do we make of these seemingly divergent findings? One interpretation could be that the relationship between GDP and an aging population is context-specific. In countries where the birth rate remains high or where the healthcare sector is a significant contributor to the economy, an aging population might not present a significant economic challenge and may even offer some economic benefits. However, in settings where the aging populace is not offset by a younger, working-age demographic, or where healthcare and social support systems are already stretched thin, an aging population could pose substantial fiscal and economic challenges. In summary, the relationship between GDP and an aging population is complex and influenced by multiple variables, including healthcare costs, labor force dynamics, and even technological advancements. Policy decisions must be nuanced and adaptable, taking into account these various factors to both leverage potential benefits and mitigate challenges. Decisions surrounding public spending, healthcare infrastructure, labor laws, and technological innovation will all play crucial roles in determining how an aging population affects GDP. As countries around the world grapple with demographic shifts, these multifaceted considerations will be essential for policymakers aiming for sustainable economic growth.

B. Aging Population with Public Budgets

The complex interplay between public budgets and an aging population continues to generate keen scholarly interest and policy considerations. Anderson's work establishes the groundwork for this debate by asserting that industrialized countries have already begun preparing for the budgetary implications of an aging population. He notes that a significant proportion of medical budgets are allocated towards elderly care. Anderson also forecasts that support programs, especially those focusing on long-term care for older women, will become increasingly crucial. His argument suggests that high healthcare costs and retirement benefits are a significant fiscal concern for countries with aging populations (Anderson & Hussey, 1999). Pammolli's research substantiates Anderson's claims, pointing out that Healthcare Expenditure (HCE) has been rising steadily. Pammolli *et al.* (2012) attributes this rise primarily to an aging population, extended lifespans, and higher income levels. He adds another layer to the discussion by implying that financial sustainability could be jeopardized if healthcare costs continue to spiral. Manton, too, provides valuable insights into the debate. He recommends that the government should proactively invest in public health and healthcare infrastructure to ensure sufficient labor force participation from older citizens. Manton's viewpoint provides a proactive solution to managing the healthcare demands of an aging population within public budget constraints (Manton, *et al.*, 2007). Contrastingly, Alda brings attention to the financial systems underpinning old age security. She explores the role of stock market development and market efficiency in pension funding schemes across 13 European countries. Alda (2017) suggests that a strong financial market can alleviate some of the budgetary pressures by providing a more substantial pension corpus. Navaneetham (2002) delves into historical data, scrutinizing the relationship between age structure and economic growth from 1950 to 1992. His analysis highlights how shifts in the age structure can have a profound impact on the investment share of GDP. These findings are essential for understanding the dynamic nature of public budgets as they adapt to demographic changes. Žokalj's research throws a cautionary note into the mix. Analyzing data from 25 EU countries, he concludes that an aging population will have negative fiscal implications. Significantly, Žokalj (2016) argues that social protection schemes would have to be modified or else risk unsustainability. Shanas adds a sociological perspective by stating that the rise of the aging population has been steady since the Industrial Revolution. He brings to light the critical issue of the variable needs within the elderly population, which often are generalized by policymakers. Shanas *et al.* (2017) argues that public budget planning for the elderly often lacks flexibility and a tailored approach, failing to accommodate the diverse needs of this demographic. Collectively, these studies provide a multi-faceted understanding of the fiscal implications of an aging population. They underline the urgent need for governments to be prudent and innovative in budget planning. This will necessitate balancing increasing healthcare and pension costs with revenue streams and other public expenditures. A critical takeaway from these academic works is that a one-size-fits-all approach will not suffice. Public budgets will need to be both flexible and targeted, addressing both the general and specific needs of the aging population. Investments in healthcare infrastructure, pension fund

management, and social protection schemes must be carefully calibrated to adapt to demographic realities, ensuring both economic viability and social justice. Future policy will thus require nuanced, data-driven approaches to manage the economic challenges and opportunities presented by an aging populace effectively.

C. Aging Population with Large Enterprise Expenditures

The evolving dynamics of an aging population in industrialized nations pose multi-dimensional challenges and opportunities, not least of which is the impact on industrial productivity and labor markets. The issue is made more complex by the demographic shifts from younger to older labor forces, leading to intricate implications for industrial employment, wages, and overall economic output. Masson provides an analytical foundation for understanding the trajectory of industrial labor in countries experiencing a demographic shift towards an older population. Utilizing modeling techniques and case studies from Japan and Germany, Masson argues that as the baby boomer generation retires, the available labor force decreases, causing a domino effect on industrial production. This decline, in turn, leads to excess demand over domestic output and a constriction in the range of products manufactured. Interestingly, Masson notes that this reduced industrial activity could strengthen exchange rates, but at the cost of decreased export rates and increased product values (Masson & Tryon, 1990). Pierson builds on Masson's work, pointing out that the demographic transition to an older population places significant and ongoing pressure on nations transitioning from secondary to tertiary industries. This adds layers of complexity to the economic landscape, as older workers may not have the skill sets required for tertiary industries, which often demand technological proficiency. Pierson (2001) asserts that the fiscal impact of an aging labor force remains an underestimated risk factor for industrial nations, especially those undergoing rapid structural transitions. Koeber takes a slightly different approach by examining the labor market itself. He notes that despite low overall unemployment rates, older workers are disproportionately represented in job loss statistics. Koeber goes on to make a counter-intuitive claim that it might be more advantageous for employers to lay off older workers, due to the cost benefits. While this may change the business structure favorably from an immediate financial perspective, it could have severe long-term implications, including loss of institutional knowledge and higher rates of unemployment among older citizens. This, Koeber suggests, could lead to a shift in wage structures and potentially depress wages for older workers (Koeber & Wright, 2001). These scholarly contributions present a nuanced tableau of the challenges and trade-offs that industrialized countries face due to aging populations. On one hand, there's a palpable pressure to sustain productivity levels, which could encourage the shifting of labor market priorities and wage structures. On the other hand, there's an urgent need to address the latent fiscal risks of maintaining an aging workforce, especially in sectors that are quickly evolving or becoming obsolete. Thus, in the context of an aging population, industrial policy can't merely focus on short-term profitability through labor cost-cutting measures; it must also contemplate the long-term socio-economic consequences of such actions. Policies should aim to re-skill older workers, thereby making the transition from secondary to tertiary industries less jarring and more sustainable. Moreover, the wage structures need to be re-evaluated to ensure that they are aligned with the changing demographics, and social safety nets should be strengthened to protect the older labor force from financial insecurities. In summary, the intersection of industrial change and aging populations necessitates a multi-pronged strategy that balances economic productivity with social responsibility. Decisions made in the industrial sector will have reverberating effects on the overall economy, and as such, must be approached with an eye towards long-term sustainability and inclusivity.

III. Raw Analysis

This section describes the trend and fluctuation of the old population amount, GDP, public budget, and storage of average in Beijing and Shanghai.

A. Aging Population

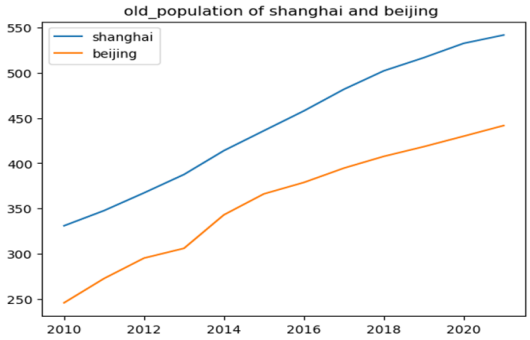

Fig. 1. Old population of Shanghai and Beijing.

Fig. 1 presents a comparative analysis of the aging population in Shanghai and Beijing over the decade from 2010 to 2020, thereby shedding light on demographic shifts in these major urban centers. In Beijing, the annual growth rate of the elderly population surged by over 20% between 2010 and 2012. However, this rate moderated to 10.8% in the subsequent year. Notably, there was a significant uptick in the annual growth rate from 306.1 to 343.1 between 2013 and 2014, marking the apex of the observed period (Ni *et al.*, 2014). Following this peak, the annual growth rate remained below 30% and exhibited a generally declining trend for the remainder of the decade. Conversely, in Shanghai, the annual growth rate of the elderly population generally exceeded that of Beijing, except in 2013, when it reached its decade-low point. On average, the annual growth rate was 16.3% in Beijing, which was marginally lower than the rate observed in Shanghai. This data illustrates the varying patterns of demographic aging in Shanghai and Beijing and offers important implications for urban planning and social welfare policies.

B. GDP

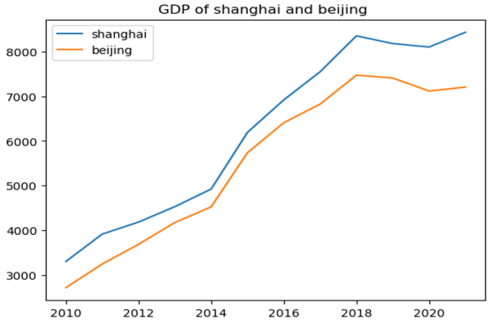

Fig. 2. GDP of Shanghai and Beijing.

Fig. 2 delineates the trajectories of Gross Domestic Product (GDP) per capita in Shanghai and Beijing from 2010 to 2021 (Ni *et al.*, 2014), providing insights into changes in income levels in these two major cities. Throughout the 11 years, Shanghai consistently exhibited a higher GDP per capita compared to Beijing. In both cities, there was a gradual improvement in GDP per capita from 2010 to 2014. This period of moderate growth was succeeded by a more pronounced increase from 2014 to 2018. However, post-2018, a declining trend was observed in GDP per capita, as it fell from 7471.43 to 7116.18 over three years. Despite this downturn, GDP per capita began to recover steadily starting in 2020. Importantly, the data suggests that an aging population does not necessarily correlate with a decline in GDP growth. While healthcare costs for the elderly may be a significant expenditure, the development of industries catering to the needs of an aging population has emerged as a crucial economic factor. Therefore, these findings indicate that the growth of the aging industry could potentially offset the economic costs associated with an aging population.

C. Public Budget

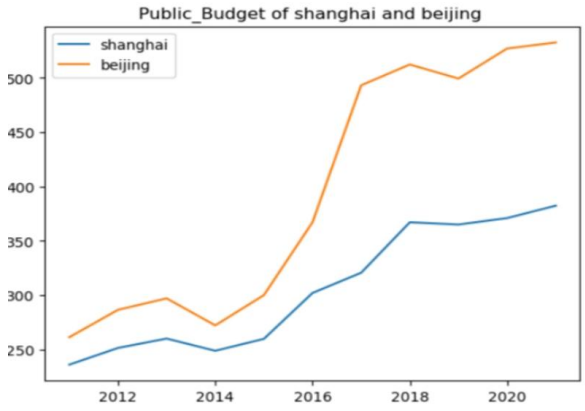

Fig. 3. Public Budget in Shanghai and Beijing.

Fig. 3 elucidates the trends in public budget allocations for Shanghai and Beijing, offering a longitudinal perspective on fiscal policies in these two major urban centers. Initially, both cities experienced a moderate escalation in public budget expenditures. Specifically, the budget grew from approximately 200 units in 2011 to just under 300 units and slightly above 250 units for Shanghai and Beijing respectively, by 2013. Subsequently, both cities witnessed a significant surge in public budget allocation, marked by a decrease of approximately one-third within a single year. This was followed by a dramatic uptick in subsequent years. One plausible explanation for this rapid escalation is the increased governmental investment in urban infrastructure. The data suggests that both cities have allocated a larger proportion of their budgets to urban development, resulting in swift increases in public spending. These trends offer valuable insights into the priorities of governmental spending in Shanghai and Beijing, revealing a substantial focus on infrastructure and urban development. The accelerated pace of public budget allocation underscores the government's commitment to invest in the long-term sustainability and growth of these cities.

D. Large Enterprise Expenditures

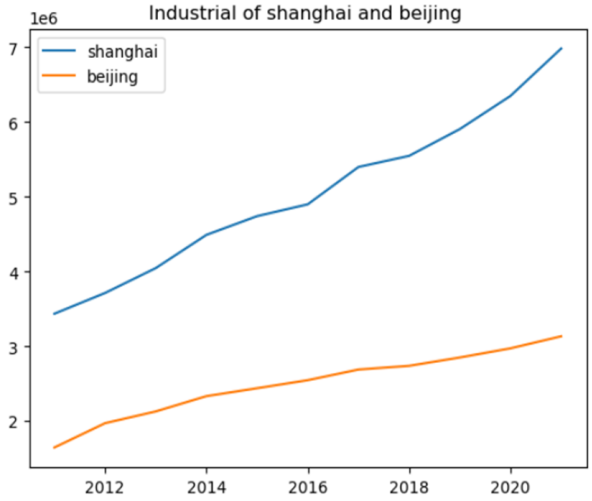

Fig. 4. Industrial in Shanghai and Beijing.

Fig. 4 provides a comparative analysis of the number of industries in Shanghai and Beijing, highlighting trends in industrial development over a decade from 2011 to 2021. Notably, Shanghai consistently maintained an industrial count of approximately twice that of Beijing throughout the observed period. In Shanghai, there was a significant increase in the number of industries, escalating from 3.5e6 in 2011 to 7e6 in 2021. Conversely, Beijing experienced a more gradual growth, with the industrial count rising by approximately 1.5 times over the same 10-year span. Several factors underpin these diverging trends. The rapid industrialization in Shanghai can be attributed to its focus on developing high-tech industries, enhancing production capabilities, and improving industrial automation. These advances potentially mitigate the impact of an aging population, as fewer manual laborers are required. On the other hand, Beijing, being the capital, serves as the political epicenter of the country, concentrating significant governmental activities. As such, the city has been more cautious in its industrial expansion. This data implicates a changing industrial landscape in both cities, thereby reducing the potential socioeconomic impact of an aging population. It suggests that strategic industrial development can serve as a mitigating factor against demographic challenges.

IV. Result

In this section, we study the relationship between the aging population economy in Beijing and Shanghai based on the three models.

A. Function 1: GDP and Aging Population

First, research the relationship between GDP and the aging population from 2011 to 2021, through the regression equation to get:

$$GDP=\alpha\_0+\alpha\_1 \text{ old population} \quad (1)$$

Null Hypothesis: $\alpha\_0=\alpha\_1=0$

Alternative Hypothesis: o.t

Through the regression of Python's stats module library, the specific results are as follows:

OLS Regression Results

Dep. Variable:	GDP	R-squared:	0.807
Model:	OLS	Adj. R-squared:	0.797
Method:	Least Squares	F-statistic:	83.49
Date:	Wed, 09 Aug 2023	Prob (F-statistic):	1.41e-08
Time:	23:19:52	Log-Likelihood:	-176.26
No. Observations:	22	AIC:	356.5
Df Residuals:	20	BIC:	358.7
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-2217.4502	929.050	-2.387	0.027	-4155.414	-279.487
old_population	20.3405	2.226	9.137	0.000	15.697	24.984

Omnibus:	0.428	Durbin-Watson:	0.407
Prob(Omnibus):	0.807	Jarque-Bera (JB):	0.541
Skew:	0.058	Prob(JB):	0.763
Kurtosis:	2.241	Cond. No.	2.38e+03

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.38e+03. This might indicate that there are strong multicollinearity or other numerical problems.

Fig. 5. The regression result between the GPD and old population.

Based on Fig. 5, the α_0is −2217.4502, the α_1is 20.3405. Since the P values of the α_0 and α_1 are both less than 0.05, which means the α_0 and α_1 are reject the null hypothesis, and the value of α_0 and α_1 are statistically significant.

B. Function 2: GDP, Aging Population, and Large Enterprise Expenditures

Secondly, research the relationship between GDP with an aging population and industry from 2011 to 2021, through this regression equation to get:

$$GDP=\alpha\_0+\alpha\_1\ old\_population+\alpha\_2\ industrial$$

Null Hypothesis: α_0=α_1=α_2=0
Alternative Hypothesis: o.t
Through the regression of Python's spasmodic library, the specific results are shown in Fig. 6 as follows:

OLS Regression Results

Dep. Variable:	GDP	R-squared:	0.951
Model:	OLS	Adj. R-squared:	0.946
Method:	Least Squares	F-statistic:	186.0
Date:	Wed, 23 Aug 2023	Prob (F-statistic):	3.33e-13
Time:	22:50:51	Log-Likelihood:	-161.07
No. Observations:	22	AIC:	328.1
Df Residuals:	19	BIC:	331.4
Df Model:	2		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-5796.4804	674.512	-8.594	0.000	-7208.251	-4384.710
old_population	37.6872	2.575	14.634	0.000	32.297	43.077
industrial	-0.0009	0.000	-7.520	0.000	-0.001	-0.001

Omnibus:	3.135	Durbin-Watson:	1.055
Prob(Omnibus):	0.209	Jarque-Bera (JB):	1.873
Skew:	-0.476	Prob(JB):	0.392
Kurtosis:	1.933	Cond. No.	3.26e+07

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 3.26e+07. This might indicate that there are strong multicollinearity or other numerical problems.

Fig. 6. The regression result between the GPD and old population with industrial.

C. Function 3: GDP, Aging Population, and Public Budget

The coefficient of the old population is 37.6872 the industrial is −0.0009, and the p-value is 0.000. The p-value is significantly lower than 0.05, which means the 37.6872 is confidence in this model. Besides, the coefficient exists in the confidence interval at a 95% confidence level.

Next, research the relationship between GDP with an aging population and the public budget from 2011 to 2021, through this regression equation to get:

$$GDP=\alpha\_0+\alpha\_1\ old\ population+\alpha\_2\ public\ budget$$

Null Hypothesis: α_0=α_1=α_2=0
Alternative Hypothesis: o.t

Through the regression of Python's spasmodic library, the specific results are as follows:

OLS Regression Results

Dep. Variable:	GDP	R-squared:	0.951
Model:	OLS	Adj. R-squared:	0.946
Method:	Least Squares	F-statistic:	186.0
Date:	Sat, 12 Aug 2023	Prob (F-statistic):	3.33e-13
Time:	10:31:15	Log-Likelihood:	-161.07
No. Observations:	22	AIC:	328.1
Df Residuals:	19	BIC:	331.4
Df Model:	2		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-5796.4804	674.512	-8.594	0.000	-7208.251	-4384.710
old_population	37.6872	2.575	14.634	0.000	32.297	43.077
Public_Budget	-0.0009	0.000	-7.520	0.000	-0.001	-0.001

Omnibus:	3.135	Durbin-Watson:	1.055
Prob(Omnibus):	0.209	Jarque-Bera (JB):	1.873
Skew:	-0.476	Prob(JB):	0.392
Kurtosis:	1.933	Cond. No.	3.26e+07

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 3.26e+07. This might indicate that there are strong multicollinearity or other numerical problems.

Fig. 7. The regression result between the GPD and old population with a public budget.

Based on Fig. 7, the α_0is −5796.4804, the α_1is37.6872 and the theα_2 are −0.0009, all p-value is zero which means the figure is confident in this model, which means the α_0, α_1 andα_2are reject the null hypothesis, and the value of α_0, α_1andα_2 are statistically significant.

V. Discussion

In this study, multiple regression models are employed to explore the relationship between the Gross Domestic Product (GDP) and the aging population, among other variables. Two distinct functions are formulated to better understand these dynamics.

A. Function 1: GDP and Aging Population

In Function 1, GDP serves as the dependent variable, while the number of aging individuals acts as the explanatory variable. Our findings suggest a positive relationship between the two. Several factors may account for this positive association:

Elderly individuals often have more significant financial resources due to years of accumulation, thereby contributing to a higher GDP.

The selection of wealthier cities for the study, namely Shanghai and Beijing, may influence this positive correlation. In such affluent urban centers, an increase in the aging population is likely to impact GDP positively.

Increased healthcare expenditures among the elderly also contribute to GDP growth, particularly due to the high cost of medical treatments and regular check-ups.

B. Function 2: GDP, Aging Population, and Large Enterprise Expenditures

In Function 2, again, GDP is the dependent variable. However, in this case, both the aging population and large enterprise expenditures serve as explanatory variables. The aging population continues to exert a positive influence on GDP, while large enterprise expenditures have a negative

impact. We postulate that:

The transition towards mechanized production and reduced labor-intensive activities may elevate turnover but can adversely affect GDP.

A focus on industries unrelated to elderly needs could result in diminished labor productivity among older workers.

Companies borrowing through financial mechanisms without providing adequate GDP returns may become particularly vulnerable in aging societies.

C. Function 3: GDP, Aging Population, and Public Budget

In this function, GDP remains the dependent variable, with the aging population and public budget as the explanatory variables. Both factors appear to positively impact GDP. Several reasons may elucidate these relationships:

Governmental investment in automation aims to enhance production efficiency but may inadvertently lead to unemployment.

Investments in high-risk technological development projects have the potential to improve living standards but may either fail or have a protracted development cycle.

Investments in senior educational initiatives aim to facilitate the reemployment of older individuals; however, these efforts may be thwarted by declining health among the elderly.

These multi-faceted findings offer insights into the complex interactions between aging demographics and economic indicators. They can serve as a foundation for future research and policy development aimed at understanding and mitigating the challenges of aging societies.

VI. Conclusion

Our research offers critical insights into the intricate relationship between an aging population and economic variables, specifically focusing on GDP in two economically vibrant cities—Shanghai and Beijing. By employing multiple regression models, we discovered that an increase in the elderly population tends to positively affect GDP. This influence is, however, modulated by other factors such as large enterprise expenditures and public budget allocations, which can exert a negative or positive impact on GDP respectively.

Given these findings, we propose several policy recommendations for government bodies:

Financial Security for the Elderly: Given that the elderly often control significant financial assets, implementing policies that ensure their financial security can have a broad, positive economic impact.

Healthcare Investment: Due to the positive correlation between an aging population and GDP, partly attributed to healthcare expenditures, increased investment in healthcare infrastructure and elderly-specific services is warranted.

Selective Industrial Focus: Our findings suggest that the expenditures of large enterprises might negatively influence GDP, particularly in an aging society. Hence, industry policies should be revised to focus on sectors that directly cater to the needs of the elderly.

Public Budget Optimization: As both the aging population and the public budget were found to have a positive influence on GDP, optimizing public budget allocations to address the needs of an aging society can enhance economic stability. This includes investing in automated technologies that can mitigate labor shortages due to an aging workforce, while at the same time focusing on sectors that can employ the elderly.

Long-Term Technological Investments: Given that high-risk, long-cycle technological investments can be precarious, a balanced portfolio that also includes short-term, low-risk projects aimed at immediate societal benefits should be considered.

Senior Education and Reemployment Programs: Investments should be made in educational programs aimed at the elderly, enhancing their skill sets for potential reemployment. These initiatives should, however, be carefully tailored to consider the physical and health limitations that may come with age.

In summary, as societies age, a nuanced approach is required to maximize the potential benefits and mitigate the challenges posed by demographic changes. The policy suggestions outlined above aim to provide a comprehensive framework for government bodies to effectively navigate the complexities introduced by an aging population.

Conflict of Interest

The author has claimed that no conflict of interest exists.

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