

Aging Population's Effect on Economic Output

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Abstract. This study investigates the economic implications of demographic aging, a phenomenon increasingly prevalent in both developed and developing countries. Utilizing the Solow-Swan model as the foundational framework for analysis, the research conclusively demonstrates that an increase in the proportion of the elderly population directly correlates with a measurable decline in aggregate economic output. This downturn is primarily attributed to escalating healthcare and pension expenditures, coupled with a diminishing labor force. The paper also conducts a rigorous evaluation of various policy interventions designed to alleviate these economic challenges. While the research explores options such as boosting birth rates, fostering technological advancements, and increasing savings rate, the study ultimately advocates for a more immediate and practical approach: the reintegration of the elderly into the labor market. Not only does this strategy sustains economic productivity, but it also capitalizes on the invaluable experience possessed by older workers. This research serves as an exhaustive resource for policymakers and scholars interested in the economic dimensions of demographic transitions.

Keywords: Aging Population; Economic Output; Social Policies; Solow-Swan.

1. Introduction

1.1. Background

It is no wonder that the world is aging. Less turbulence in life created better living conditions around the world. In the meantime, life expectancy continues to grow despite diseases and natural disasters. All of these led to an increased number of births starting from the 1950s (see Figure 1).

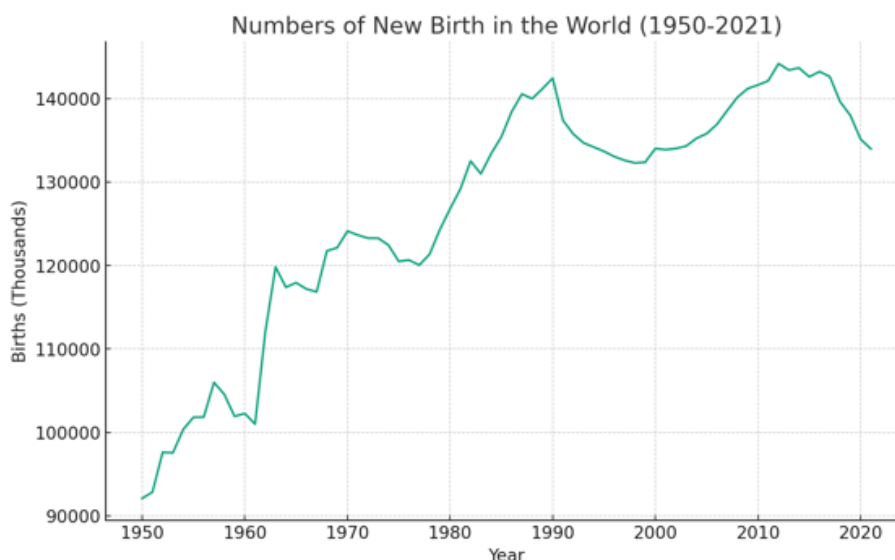


Fig 1. Number of New Births in the World from 1950 to 2021 [1].

However, this boom in population created another issue: An aging population. Due to the international standard of classifying elders as people over 65 years old, this meant that all populations born at and before 1958 were officially entering the elder period. Not only the current society is facing more elders, but with urbanization and increasing pressure of living among the younger generation, elders are taking a much bigger fraction of society, leading to an aging population, in which countries that developed mainly around the 1950s are affected the most. In Figure 2, we can see that due to the

accelerated growth of population, China is projected to have a much higher Elderly Percentage in the future, which India converges with the US around the 2100s.

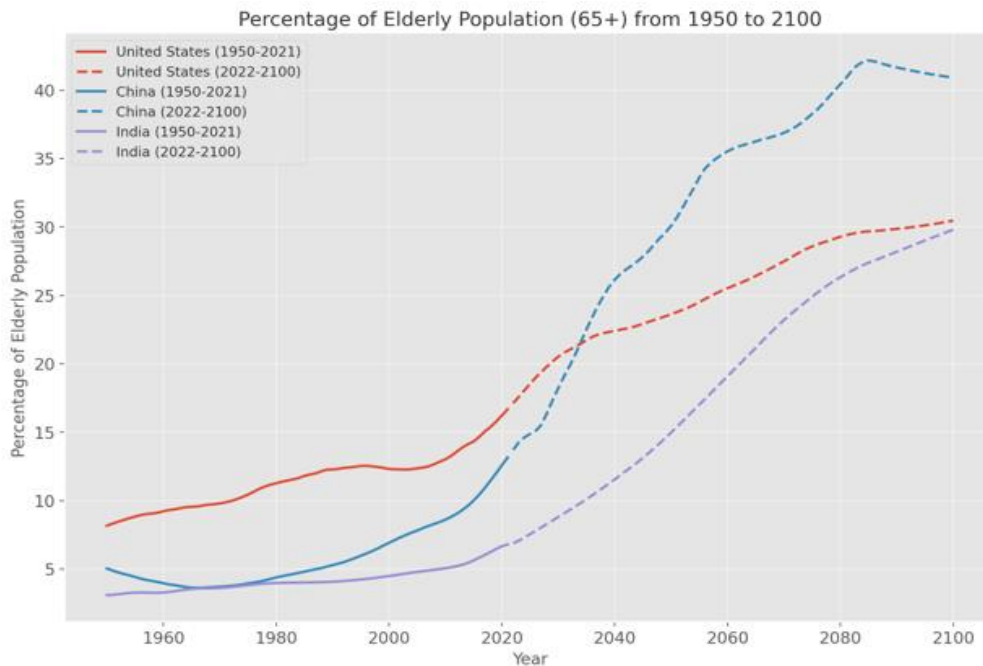


Fig 2. Percentage of Elderly Population Projection to the 2100s of China, US and India [2].

Developed, Asian countries and some European countries are facing this issue more significantly than other countries. A great indicator of this issue is the Dependency ratio, which is the number of elders over the number of people of the working age. This means that every person of working age would have to carry the pressure of that number of elders. In 2060, Japan is projected to have a dependency ratio of over 80%, while China, Germany, and Finland are around 60-80% (See Figure 3). This is crucial because in the future, not only the society has more elders, but on the other hand have fewer working adults, therefore requiring a much higher productivity of these working adults.

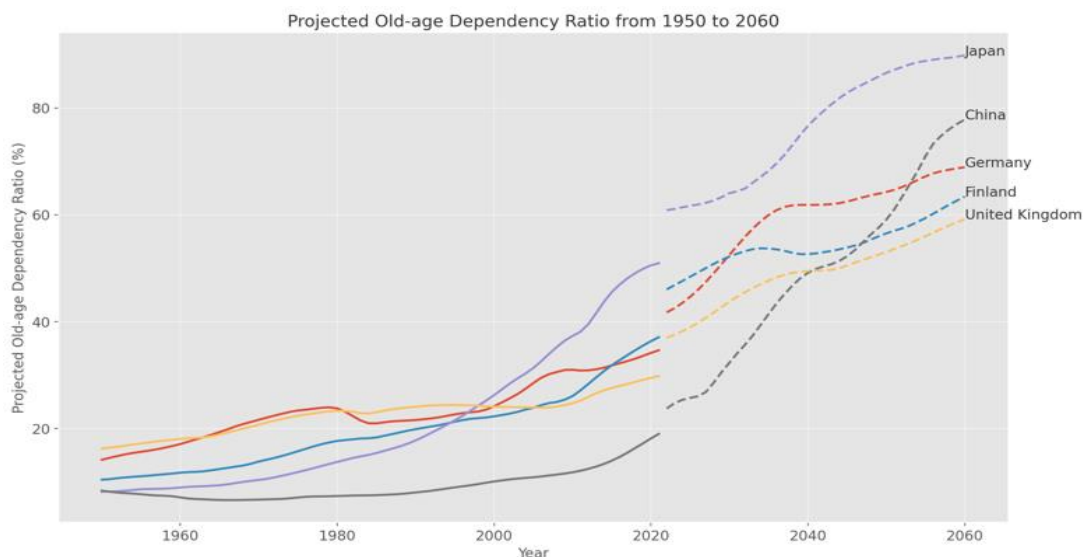


Fig 3. Projected Old-age Dependency Ratio of Japan, China, Germany, Finland, and UK from 1950 to 2060. [2, 3].

There are several consequences of an aging population, including more healthcare expenditures and higher depreciation. First, more expensive healthcare. For a government experiencing an aging population, to keep the elders healthy, they would need to spend more than before. Figure 4 is a comparison of Life Expectancy against Health Expenditure per capita in 2016. In this chart, we see a

diminishing return for spending more per capita in return for life expectancy. Despite that, many countries still choose to spend more for better life expectancy, especially in well-developed countries. These countries often face ethical concerns, and even maybe backlashed because a lower health expenditure may cause lower happiness in a family, and elders are still a major consumer group, so a low life expectancy may also reflect on the general economy.

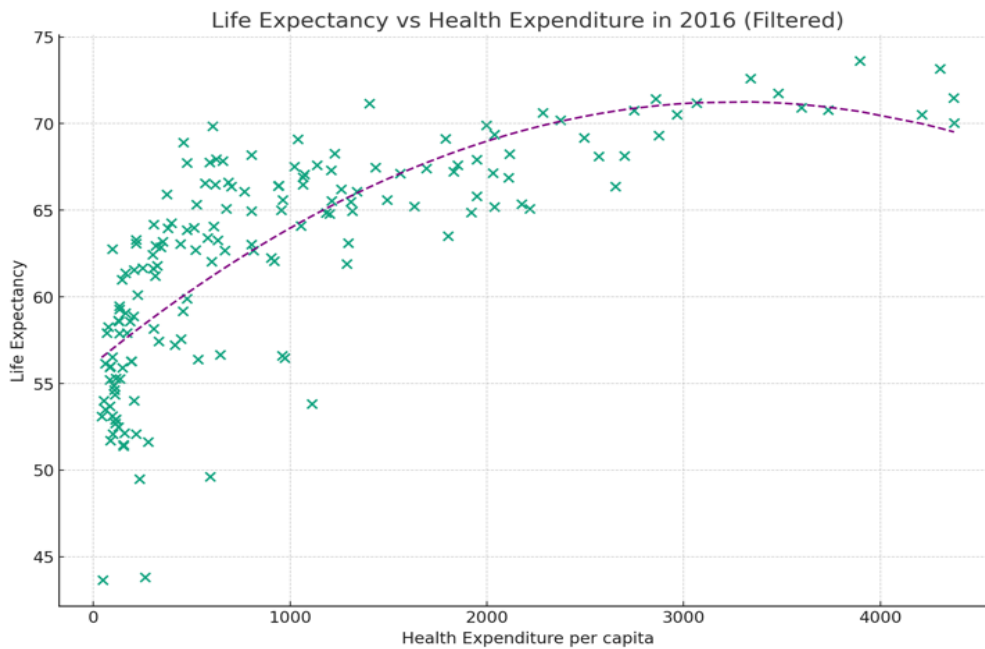


Fig 4. Life Expectancy vs Health Expenditure in 2016 [4].

Depreciation is also a large factor caused by an aging population. To support this population, the government would have to build facilities such as Eldercare centers, retirement communities, and local parks to support these elders. In an aging society, not only the government needs to build new facilities, but also maintain and constantly fund those that are already built. This increases the expense every year and it is reflected substantially in Scandinavian countries, such as Finland and Sweden, which are known for their high social welfare level (See Figure 5).

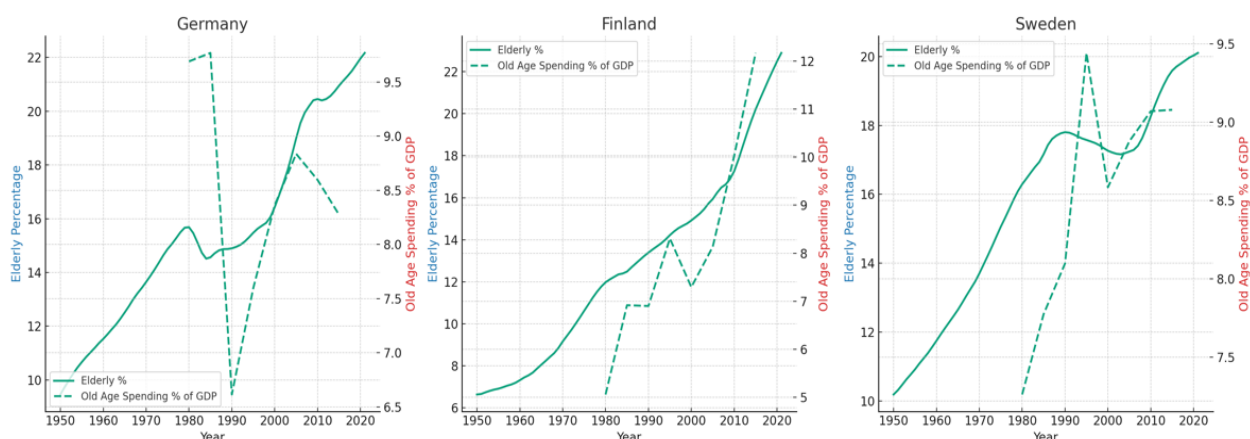


Fig 5. Old Age Spending Compared to Elder Percentage in Germany, Finland, and Sweden. [2, 5].

1.2. Significance and Objective

With an aging society, it would be necessary to understand the relationship that this trend may cause. Therefore, the paper aims to find the trend of aging against the output of society. A not aging society with the same conditions would be used as a control group to see the difference in aging. Also, the paper will also measure the effectiveness of two popular policies around the world, and give following recommendation.

2. Methodology and Findings

2.1. Variable Introduction

Table 1. Definition of variable.

Variables	Definition
P	Population in the model
A	Technology in the model
SR	Savings Rate
DR_{ini}	Initial Dependency Ratio
DR_i	Dependency Ratio Increment
$C_{healthcare}$	Healthcare Cost
$C_{pension}$	Pension Cost
$FB_{healthcare}$	Flowback Ratio of Healthcare expenses
$FB_{pension}$	Flowback Ratio of Pension expenses
α	Output elasticity of capital
β	Output elasticity concerning DR
Dep_R	Depreciation Rate

2.2. Model Establishment

2.2.1. Assumptions

This model does not consider technological growth. Technological growth is hard to model, as few statistics could reflect a realistic growth of output. Also, technological advancement increases the output directly, so it disturbs the raw effect of aging on output effects.

This model does not consider productivity difference of different age groups. Despite that there is evidence that shows the productivity decreases over time, it creates minimal effect on the general economy. For simplicity, this difference is neglected.

Individuals are considered equal in the model. Despite in the real life, inequality and personal choices causes drastic differences, such as higher healthcare cost, lower savings, but for simplicity, everyone are considered same in the model.

2.2.2. Model

This model is based on the Solow-Swan model, which models output with output, depreciation, and investment. The Cobb-Douglas function, predecessor of the Solow-Swan model, is modeled with equation (1).

$$Y(t) = K(t)^\alpha (A(t)L(t))^{1-\alpha} \quad (1)$$

With the Solow-Swan model, the output is based on the Capital, Technology, Labor, and elasticity of output, in the range of $0 < \alpha < 1$. Depreciation and savings could be reflected in equation (2).

$$K'(t) = (1 - SR) \times Y(t) - DepR \times K(t) \quad (2)$$

Healthcare is an important section of an aging society. In this model, healthcare would be provided to elders, and considering the fact that a fraction of the healthcare spending would return back to the society such as wages, we introduce a flowback ratio to model the scenario.

Similar to healthcare, pensions are also a major part of old age spendings. As we consider that pension also has a majority of it flowing back, a flowback ratio is also introduced to model the scenario. A pension fund pool that is based on a fixed percentage of the GDP is created so that the pension per elder changes dynamically as the GDP grows. With regression of using real-world data [5], we can find the cost of healthcare and pension with equation (3) and (4).

$$C_{healthcare} = 0.0493GDP_{cap} + 927.14 \quad (3)$$

$$C_{pension} = Y_{total} \times FP_{pension} \quad (4)$$

Savings is also an important part of the model. Net savings in each year would be modeled by equation (5).

$$\Delta S = Y - C_{pension}(1 - FB_{pension}) - C_{healthcare}(1 - FB_{healthcare}) \quad (5)$$

Therefore, the output could be found with equation (6).

$$Y = A \times K_{control}^{\alpha} \times L_{control}^{1-\alpha} \quad (6)$$

In each iteration, the capital would be modified with equation (7).

$$K_{control_{new}} = S_{net} + K_{control_{prev}}(1 - DepR) \quad (7)$$

For the aging society, we would be using $DR_{new} = DR_{prev} + DR_i$ to model the increase of dependency ratio. As following, the output would be modeled from equation (8).

$$Y_{exp} = A \times K_{exp}^{\alpha} \times L_{exp}^{1-\alpha} \times D_{exp}^{\beta} \quad (8)$$

2.3. Result and Analysis

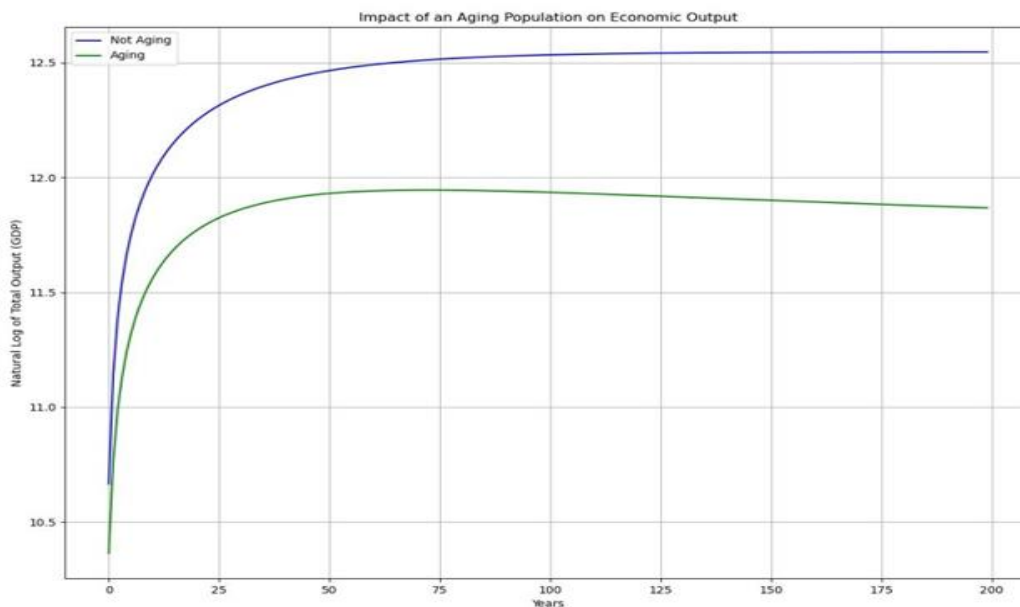


Fig 6. Modeled result of Aging Population through higher dependency ratio.

Figure 6 displays the result of the simulation after 200 years. In the diagram, the X-axis is the number of years, and the Y-axis is the natural log of Total Output, equivalent to the National GDP in the model. Both scenarios display a growth in the first 50 years, with the control group displaying a much higher output than the experiment group. Afterwards, the experiment group experience drops in total output, due to a higher dependency ratio that caused a higher healthcare and pension expense for the government. Therefore, it is evident that an aging population does decrease the total output of a society over a period of time. This could be explained as the dependency ratio rises, the cost of healthcare and pensions rises, and the labor force decreases, producing less output as before. The two factors combined caused the total output to drop.

3. Policy Reviews and Impacts

3.1. Policy Introduction

To address the pressing issue of an aging population, several countries have formulated policies aimed at mitigating the associated socioeconomic consequences.

Firstly, one prevalent approach is to encourage higher birth rates to decrease the dependency ratio. This strategy directly tackles the core issue. However, its implementation poses challenges, as it is

not feasible to mandate procreation. Instead, the focus is on incentivizing young couples to have children. Various methods to achieve this goal include financial bonuses, targeted advertising campaigns, and the development of public infrastructure that eases the burdens of parenthood. For instance, China has implemented measures such as reducing the prominence of cram schools, offering housing incentives, and subsidizing childcare to reduce the pressure of parents [6, 7, and 8].

Secondly, another method involves the promotion of technological innovation to boost economic output. Advancements in technology can significantly elevate productivity levels and, by extension, improve living conditions. Despite its potential efficacy, this approach carries risks, often requiring substantial investment in specific sectors. Furthermore, certain fields may be vulnerable to sanctions or failures that hinder productivity growth.

Lastly, some nations have tried to extend the retirement age or to advocate for more elders to continue to participate in work. This policy is particularly beneficial for multiple reasons. Older workers "tend to have both high incomes compared to younger cohorts...and high needs" [9], making their continued employment advantageous. Their extensive experience also often makes it more practical for companies to retain them rather than ushering them into retirement. This model is notably prevalent in European and North American countries, which have a larger proportion of older residents compared to developing nations. For example, in England, there are 61% more people above 70 working compared to 2012 [10].

3.2. Policy Modeling

Considering the complexity and feasibility of policies, two policies are chosen. They are increasing the savings rate and increasing the working population policies.

For the policy of increase Savings Rate, the model changes the original savings rate of 20% to 30%, signifying a change. For the policy of increasing working population, this policy allows elders to re-enter the working population. However, unlike the increased working population policy, this model does not change the dependency ratio. In the model, it is set that 35% of the elders participate in working, based on the projection of OECD to 2030 [11].

3.3. Result and Analysis

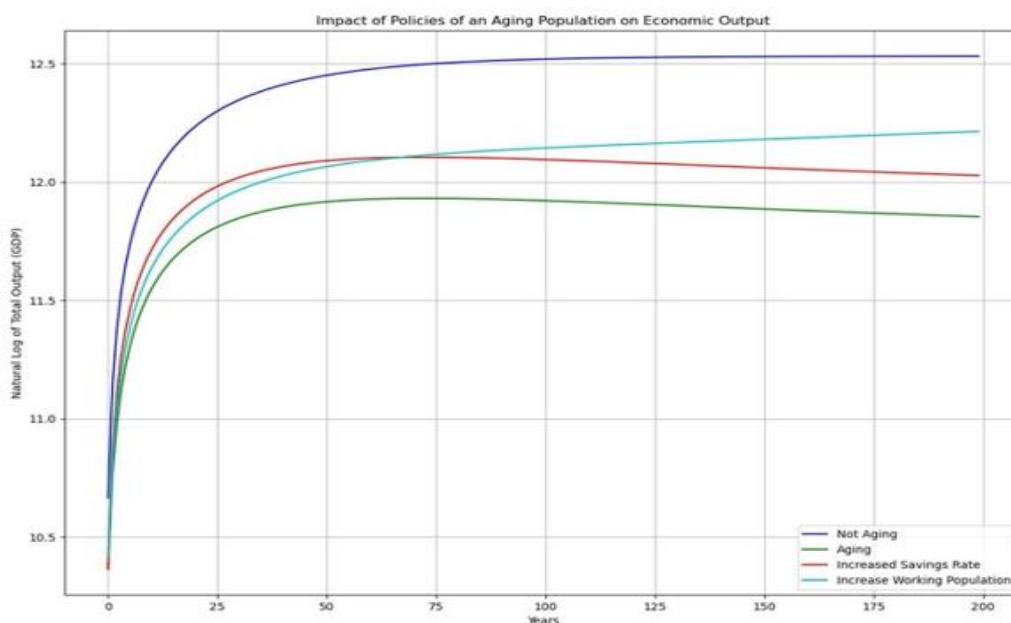


Fig 7. Modeled result of Impact of Policies of an Aging Population.

In Figure 7, it demonstrates the effects of the policies' impact on the output. From the result, it can be concluded that an increased savings rate could compensate for the growth, but on the long term it is not as effective as introducing an increase working population policy. Therefore, increasing working population policy is recommended.

In the increased savings rate model, we see a higher output than the experiment group due to the capital accumulation that leads to higher output through the calculation with the Cobb-Douglas function. However, it is noticeable that in the long-term, this did not bring benefits to the economy and did not sustain the growth.

The increase working population policy performs the best as it mitigates the disadvantage of an aging population, bring the retired people back for output. This also follows the trend of an aging workforce in the current situation, and it would be relatively easier to support.

4. Conclusion

This study leverages the Solow-Swan economic model to investigate the economic impact of an aging population. The findings reveal that an aging demographic imposes a substantial burden on healthcare and pension systems, consequently reducing overall economic productivity. The study suggests to incorporate elders into the workforce to increase economic output, providing a statistical insight to the effect.

However, the study also highlights the variability of these impacts across different regions and social groups. Therefore, it recommends that policymakers adopt localized strategies, taking into account cultural and social factors, rather than a one-size-fits-all approach.

For future research, the study suggests exploring the role of technological advancements in offsetting the economic challenges posed by an aging population. Additionally, a comparative analysis of the effectiveness of various policies in different cultural and economic settings could provide valuable insights for policymakers.

References

- [1] Our World in Data, "Annual number of births by world region," Our World in Data, Sep. 09, 2022. <https://ourworldindata.org/grapher/annual-number-of-births-by-world-region>
- [2] United Nations, Department of Economic and Social Affairs, Population Division (2022), "World Population Prospects 2022, Online Edition," 2022.
- [3] Our World in Data, "Old-age dependency ratio," Our World in Data, Sep. 09, 2022. <https://ourworldindata.org/grapher/age-dependency-ratio-old>
- [4] Our World in Data, "Life expectancy vs. healthcare expenditure," Our World in Data, May 29, 2023. <https://ourworldindata.org/grapher/life-expectancy-vs-healthcare-expenditure>
- [5] Our World in Data, "Social expenditure as share of GDP," Our World in Data, Oct. 15, 2019. <https://ourworldindata.org/grapher/social-expenditure-as-percentage-of-gdp?time=2015..latest> (accessed Sep. 18, 2023).
- [6] The Economist, "China is clamping down on cram schools," The Economist, Jun. 24, 2021. <https://www.economist.com/china/2021/06/24/china-is-clamping-down-on-cram-schools>
- [7] G. Times, "China's populous Guangdong issues more favorable housing polices to support multi-child families - Global Times," www.globaltimes.cn, Jun. 08, 2023. <https://www.globaltimes.cn/page/202306/1292205.shtml> (accessed Sep. 18, 2023).
- [8] J. Liang, "Child care subsidies can help address China's population crisis," Nikkei Asia, Aug. 06, 2023. <https://asia.nikkei.com/Opinion/Child-care-subsidies-can-help-address-China-s-population-crisis> (accessed Sep. 18, 2023).
- [9] W. Fengler, "The silver economy is coming of age: A look at the growing spending power of seniors," Brookings, Jan. 14, 2021. <https://www.brookings.edu/articles/the-silver-economy-is-coming-of-age-a-look-at-the-growing-spending-power-of-seniors/>
- [10] R. Davies, "British workers increasingly likely to work into their 70s, research suggests," The Guardian, Apr. 30, 2023. Available: <https://www.theguardian.com/society/2023/apr/30/british-workers-work-into-70s-cost-of-living>
- [11] OECD, "The Silver Economy as a Pathway for Growth Insights from the OECD-GCOA Expert Consultation," Jun. 2014.