The Impact of Population Aging on Risk-free Rate

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Abstract: This study delves into the relationship between the long-term trend of population aging and the risk-free rate against the backdrop of China's diminishing demographic dividend and declining birth rate. It further examines the mechanisms via which population aging affects the risk-free rate. The phenomenon of population aging is distinguished by a rise in the percentage of older individuals and a decline in the percentage of younger individuals, hence exerting a diverse range of effects on the economy. The demographic transition holds significant influence over savings, investment, labor supply, and interest rates, making it a crucial macroeconomic issue. This study employs a literature review methodology and conducts data analysis to construct a "elderly population ratio" framework grounded in life cycle theory. The objective is to investigate the correlation and knowledge significance of the risk-free rate.

Keywords: population aging, inflation; risk-free rate, nominal interest rate

1.   Introduction

One of the pressing subjects in current economic discourse pertains to the interplay between demographic shifts, particularly the process of aging, and the worldwide financial environment [1]. The economic implications of the demographic shift characterized by a growing senior population in global countries have been extensively examined in several research works [2]. One of the primary factors influencing this phenomenon is the impact of interest rates, particularly those pertaining to risk-free nominal interest rates.

The risk-free interest rate pertains to the rate of interest that can be acquired through the investment of funds in an object of investment without any associated risk. The investment return, which is subject to the benchmark interest rate, might be considered as an optimal outcome. The interest rate serves as remuneration for both opportunity cost and risk. Specifically, the remuneration for opportunity cost is referred to as the risk-free interest rate [3]. Risk-free nominal interest rates are widely considered to be fundamental in financial analysis, as they serve as a reference point for numerous financial instruments and significantly influence investment and savings choices. Throughout history, a multitude of factors, including monetary policy, global economic conditions, and investor expectations, have had influence on the trajectory of the subject under discussion [3]. Nevertheless, the equation pertaining to the change into an aging population introduces a novel and significant variable.

The issue of population aging in numerous industrialized economies is mostly attributed to two factors: the decrease in birth rates and the increase in life expectancy. Simultaneously, the long-term

risk-free rates in several countries have exhibited a persistent downward trend over the past few decades. A comprehensive grasp of the interconnection between these two prevailing patterns is crucial for the formulation of macroeconomic policies, effective fiscal management, and informed investment choices [2].

The impact of the aging population on risk-free nominal interest rates is multifaceted. One potential consequence of the growing share of elderly individuals in the population is a potential rise in savings and subsequent decrease in interest rates [4]. Contrarily, due to the potentially shorter investment horizon and increased propensity for consumption among the senior demographic, there exists the possibility of upward pressure on interest rates. It is imperative to thoroughly investigate these potential influences and other pertinent elements [5]. The primary objective of this study is to conduct an in-depth examination of the intricate correlation between the aging population and the risk-free nominal interest rate. This analysis will encompass both the theoretical framework and empirical evidence, allowing for a comprehensive understanding of the subject matter. This analysis aims to elucidate the wider economic ramifications of population dynamics and offer valuable insights for policymakers, investors, and other stakeholders within the financial sector.

2. Overview

The risk-free interest rate is a fundamental concept in the field of asset pricing and asset allocation. The risk-free interest rate is a theoretical construct that quantifies the foregone opportunities associated with investing, and is not readily observable in practice. The selection of a risk-free rate as an observable proxy indicator is not a singular choice for many institutional and individual investors [1]. Large institutional investors typically opt for the 3-month treasury bond yield or the interbank lending rate as their preferred risk-free yield. On the other hand, individual investors tend to gravitate towards the time deposit interest rate or currency as their more relevant risk-free interest rate. The rate of return on an investment. In the event of a continued split, it is possible to partition these nominal interest rates devoid of risk into inflationary and risk-free real interest rates. The influence of inflation and natural interest rates is contingent upon the age structure of the population, as posited by the production function and life cycle theory. The fundamental focus of the investigation of the enduring correlation between population and risk-free nominal interest rates lies in comprehending the influence of population dynamics on inflation and natural interest rates. This article focuses on the risk-free interest rate and does not delve further into its subdivisions.

The fluctuations in risk-free interest rates can be categorized into two distinct types of factors. The first type pertains to cyclical factors, which encompass the influence of financial cycles, monetary policies, and various other factors on risk-free interest rates. The second type relates to structural factors, which contribute to changes in the long-term trajectory of risk-free rates. These structural factors include technological advancements, population growth and age demographics, income inequality, and other relevant considerations. The decline in risk-free interest rates in industrialized countries can be attributed to several variables, including the demand for secure assets. Among these factors, the age structure of the population plays a significant role in explaining this downward trend [6]. Over the course of the last four decades, industrialized nations in Europe and America have exhibited a consistent decline in risk-free interest rates. Beginning at approximately 7% in the early 1980s, these rates have gradually diminished to reach approximately 0% in 2021. Notably, many countries, including the UK, have even experienced negative interest rates [6].
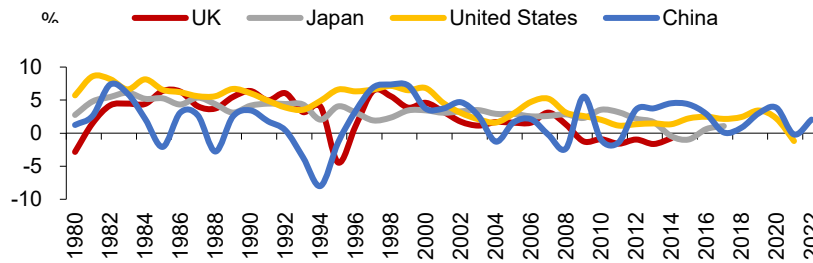
Figure 1: Long-term real interest rates in developed countries have continued down (source: World Bank)

The fluctuations in the risk-free rate can be predominantly attributed to population factors. According to the study conducted by Sudo and Takiuka, it was observed that the risk-free interest rate in Japan experienced a significant fall of 640 basis points (bp) between the years 1960 and 2015. The researchers further suggested that the demographic patterns prevalent during this period might potentially account for a decline of 270 basis points (bp) [7]. According to Papetti's research, there is evidence to suggest that population changes inside the eurozone have resulted in a reduction of the risk-free rate by 1 percentage point for the period spanning from 1990 to 2030 [8]. According to the research conducted by Platzer and Peruffo, it has been determined that the decline in the risk-free rate in the United States can be attributed to three primary factors: income inequality, demographic changes, and a decrease in productivity growth. These factors have been found to have a significant impact on the risk-free rate, resulting in a reduction of 0.70, 0.71, and 1.0 percentage points, respectively [9].

The influence of population factors has had an adverse effect on the risk-free rate in both developed and emerging economies. Since 2011, a distinction has been made between developed and emerging economies in terms of the trajectory of the risk-free rate. The risk-free rate of developed countries has exhibited a period of stability, followed by a transition into negative territory subsequent to 2017, and then underwent a significant fall beyond 2020 [8]. Simultaneously, emerging economies have had a consistent increasing trajectory followed by a subsequent decrease across all regions from the year 2018. One of the significant aspects contributing to the differentiation of total factor productivity growth is the driving force behind this trend [9]. It is noteworthy to acknowledge that demographic variables have exerted a detrimental influence on the risk-free rate in both developed and emerging countries. Specifically, Japan, Germany, and China have experienced the most significant negative impact on the risk-free rate, causing a decline of more than 1 percentage point [8].
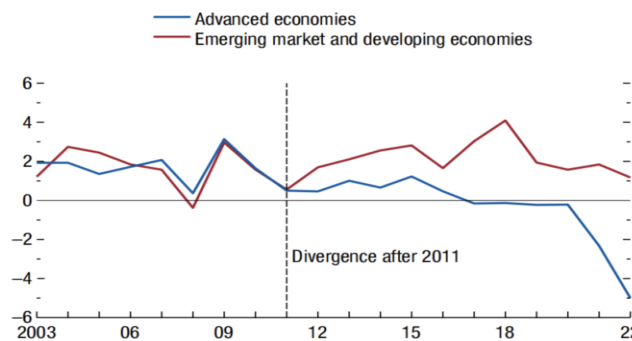

Figure 2: The real interest rate trend of developed and emerging economies has diverged (Source: IMF)

Various demographic characteristics, such as alterations in the rate of population growth and age distribution, together with the prolongation of life expectancy, exhibit distinct processes of influence on the risk-free rate. Theoretical considerations suggest that the influence of demographic characteristics on the risk-free rate can be understood through three distinct elements.

To begin with, the decrease in the availability of labor has resulted in a decrease in the risk-free rate. The decline in the rate of labor population growth results in a gain in per capita capital, a reduction in capital demand for companies, and a fall in marginal capital production. The aforementioned alteration aligns with an internal movement of the capital demand curve, resulting in a downward impact on the risk-free rate.

One additional factor to consider is that the increase in life expectancy exerts a negative influence on the risk-free rate. When the retirement age remains constant, the prolongation of life expectancy results in a rise in the duration of post-retirement period. From the standpoint of life cycle theory, the augmented need for consistent spending prompts a rise in the savings demand among young individuals, thus leading to an increase in the supply of capital. The observed change aligns with the outward movement of the capital supply curve, resulting in a downward impact on the risk-free rate.

Furthermore, the rise in the percentage of older individuals exerts an increasing influence on the risk-free rate. The decline in population growth has the eventual consequence of increasing the dependency ratio, whereby the retired population exhibits a decreased propensity for saving compared to the working-age population. The alteration in population composition results in a decline in the overall savings rate, resulting in an inward tilt of the capital supply curve and generating upward pressure on the risk-free rate.

In general, demographic considerations have a negative impact on the risk-free rate. Miles et al. shown that over the period of 1990 to 2014, population dynamics in industrialized nations resulted in a decline of 1.5 percentage points in the risk-free rate. Furthermore, the substantial influence of an augmented life expectancy can be predominantly accounted for [10]. According to Papetti's findings, the three impact mechanisms in the eurozone exhibit time-varying characteristics in terms of both direction and size [8]. Following the year 2010, the adverse impacts of life expectancy and labor supply have come to outweigh the risk-free rate. The ongoing decrease in labor supply and the prolonged increase in life expectancy will persist in placing downward pressure on the risk-free rate. According to data derived from the Eurozone, the forthcoming decade is projected to witness varying degrees of influence from three mechanisms. These mechanisms can be ranked as follows: the negative impact resulting from higher life expectancy, followed by the negative impact stemming from reduced labor supply, and finally, the positive impact arising from an increased proportion of older individuals [8].

The two main channels through which population aging may affect risk-free rate include: 1) through the hypothesis of excess savings; 2) through the decline in investment demand.

The Savings Glut Hypothesis has emerged as a prominent economic theory in contemporary discourse, mostly aimed at elucidating the persistent decline in global long-term interest rates. The fundamental premise of this hypothesis posits that the expansion of worldwide savings surpasses the rate of investment growth, resulting in a surplus of funds and thus exerting downward pressure on global interest rates. Elderly individuals exhibit a propensity for higher levels of savings, resulting in an augmented supply of loanable funds, thereby exerting downward pressure on interest rates. In light of the life cycle hypothesis, it is observed that individuals exhibit a propensity to increase their savings as they approach the retirement stage. Consequently, there is a gradual buildup of monetary resources. The augmentation of savings (or loanable funds) and the disproportionate augmentation in investment demand will lead to a reduction in the equilibrium interest rate.

Another possible channel is the decline in investment demand: the decrease in the young population may lead to a decrease in the demand for capital and investment, resulting in a decline in

interest rates. The decrease of the young population means a decrease in the labor force, which may reduce productivity and capital demand. The aging of the population may put the consumption of non-durables above durable goods, resulting in reduced investment in capital-intensive industries.

3.   Methodology and Empirical Evidence

The examination of the data of developed economies, especially countries with a significant degree of population aging, such as Japan, usually shows the correlation between population aging and low risk-free rate. The influence of population aging on the risk-free rate and inflation is characterized by several mechanisms, which are substantiated by the life cycle theory. The correlation between the age composition of the population and the risk-free interest rate is discernible, but the association with inflation exhibits a non-linear pattern. The objective is to identify shared characteristics and subsequently verify them using empirical interest rate data. This article selects the yield of maturity of the ten-year treasury bonds of the National Bureau of Statistics of China from 2002 to 2022 and the maintenance ratio of the elderly population. The data are as follows.

Table 1: The specific situation of China's dependency ratio of the elderly population and the yield of ten-year treasury bonds in 2002-2022 (Source: National Bureau of Statistics of China)

Year	Old (%)	risk-free rate (%)
2022	21.80	2.7667
2021	20.82	3.0290
2020	19.74	2.9441
2019	17.80	3.1791
2018	16.77	3.6222
2017	15.86	3.5798
2016	15.00	2.8576
2015	14.33	3.3686
2014	13.69	4.1557
2013	13.08	3.8265
2012	12.66	3.4596
2011	12.25	3.8601
2010	11.90	3.4699
2009	11.60	3.3366
2008	11.33	3.9153
2007	11.10	3.9921
2006	10.96	3.0445
2005	10.67	3.7723
2004	10.69	4.5475
2003	10.65	3.1501
2002	10.38	2.9906

The following figure shows the trend chart of the two indicators, which can be more intuitive and clearly seen that there should be a negative correlation between the two.
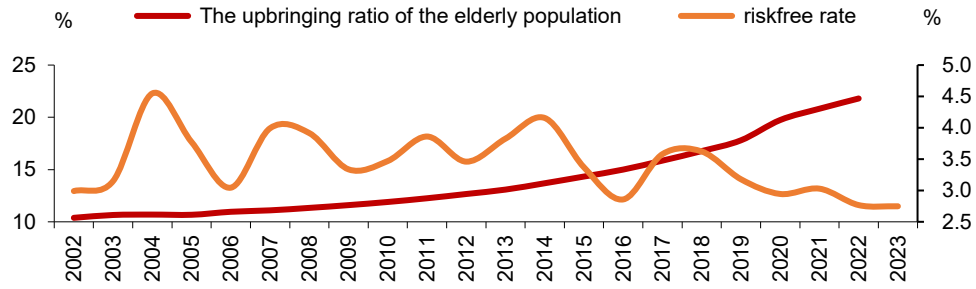
Figure 3: The tendency of China's dependency ratio of the elderly population and the yield of ten-year treasury bonds in 2002-2022 (Source: China National Statistics Bureau)

The theoretical underpinnings of the measurement model employed in this paper are derived from the life cycle hypothesis and the family savings demand model [11-12]. The life cycle hypothesis categorizes the income of the working-age population into three distinct components, namely self-consumption, child-rearing, and retirement savings, based on micro-consumer behavior. Furthermore, it should be noted that personal savings are subject to variation throughout different stages of the life cycle. Due to the lack of income, the elderly population needs the support of their children or overdraft their own pre-retirement savings due to the lack of income, these two groups are negative savings, and the income of the working-age population is greater than consumption, and positive savings will be carried out. From this, we can think that if the proportion of the elderly population to the working-age population is larger (the old-age ratio), the risk-free interest rate (savings rate) of this economy can be expected to decline. Therefore, the following assumptions are proposed according to the classic life cycle theory:

Hypothesis H1: Elderly support ratio and the risk-free interest rate are inversely related.

Therefore, in order to test the relationship between the population structure and the risk-free interest rate, the author constructs the ratio of the aging of the elderly population as an indicator of the aging of the labor force [13].

$$\text{Elderly support ratio} = \frac{\text{Elderly population of 65 and over 65 years old}}{\text{Working} - \text{age population aged } 15 - 64} \times 100\%$$

The higher this indicator, the higher the aging of the labor force.

In addition to examining the trend chart acquired in the workplace, one may also employ Stata software for doing regression analysis. It can be found that the coefficient is significantly negative. It is initially believed that there is a direct negative correlation between the two, assuming that H1 is true.
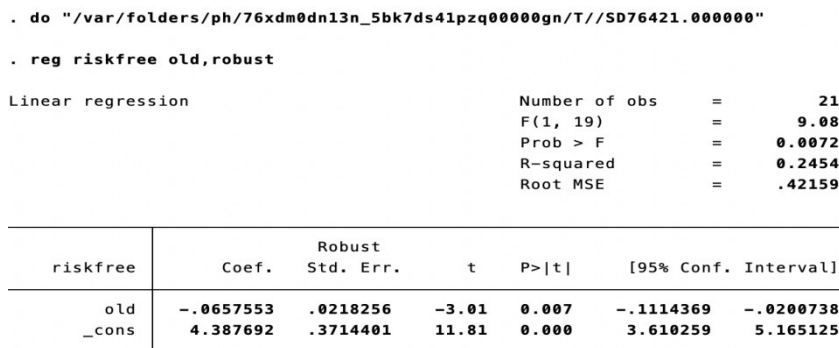
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. reg riskfree old,robust

Linear regression                               Number of obs   =         21
                                                F(1, 19)        =       9.08
                                                Prob > F        =     0.0072
                                                R-squared       =     0.2454
                                                Root MSE        =     .42159

                          Robust
    riskfree |    Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
         old | -.0657553   .0218256    -3.01   0.007    -.1114369   -.0200738
       _cons |  4.387692   .3714401    11.81   0.000     3.610259    5.165125
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Figure 4: Regression results of elderly dependency ratio and risk-free interest rate

4. Conclusion

The phenomenon of population aging pertains to the escalation in the relative representation of aged individuals within a given population. The aforementioned shift in demographics has influence on various economic sectors, including the risk-free interest rate. Based on established economic theory and actual study, it is posited that population aging has the potential to exert a lowering influence on risk-free interest rates. By doing an analysis on the influence of population aging on risk-free interest rates, many key findings may be derived: First of all, aging may lead to an increase in the savings rate. Older people may increase their savings before retirement to prepare for retirement. The increase in savings will lead to an increase in the supply of funds, which may reduce the risk-free interest rate. Secondly, the aging of the population may reduce investment. As the working-age population in the labor market decreases, enterprises may reduce their investment in new technologies and capital, leading to a decline in investment demand and further lower interest rates. Finally, through the empirical study of the data, we can see that with the increase of the dependency ratio of the elderly population, the risk-free interest rate is gradually decreasing. In short, although other factors also affect risk-free interest rates, the aging of the population is an important macroeconomic factor, which may lead to a decline in interest rates.

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