The Impacts of Demographic Changes on Pension Scheme and Capital Market Returns

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Introduction

- How can pension schemes be sustainably financed?
- Due to the increased ratio of people in retirement relative to people of working age there are serious financial problems for pay-as-you-go financed pension systems.
- But the aging population has also negative effects on a capital funded pension system since the capital market return will drop due to the demographic change.
  - The capital intensity increases since the capital funded pension schemes initiate a higher capital accumulation in the whole economy. This leads to a price increase for the factor workforce and to a price decrease for the factor capital.
  - Due to the many retired sellers and the low number of young buyers, the prices of the assets (shares, bonds, real estate etc.) must fall.

The Model

- The model consists of three building blocks:
  - a population model which describes the presumptions with respect to population development,
  - modeling of enterprises in view of the dependence between the existing pension system and the real economic variables such as wage and capital stock and
  - description of risks on financial markets as well as the interactions between pension systems and stock prices or interest rates.
- Furthermore, we will examine the effects of pension systems on welfare distribution and consumption as well as the rate of saving within generations.

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Population model

- The population consists of $J + 1$ generations. All consumers live for exactly $J + 1$ time steps (**overlapping generations model**) and exhibit a homogeneous savings and consumption behavior.
- Each generation is identified in each period by an index $j = 0, \ldots, J$ that describes the remaining life expectancy.
  - $j = J$ is the youngest generation to be born at the beginning of the considered period,
  - $j = 0$ represents the oldest generation that dies at the end of the period.
- The population is modeled by age-dependent birth rates :

$$\mathrm{N}\,(N_{t-1}) = \sum_{j=0}^{J} N_{t-1}^{(j)} n^{(j)} \left(1 + \exp\left(-n_2 \sum_{i=0}^{J} N_{t-1}^{(i)}\right)\right).$$

Population model

- There is a retirement threshold j_L for the consumers. Each member of the working generation ($j = j_L, \ldots, J$) provides $L^{(j)}$ units of labor and gets the net wage:

$$e_t^{(j)} = (1-\tau_t)\omega_t \overline{L}^{(j)}, \quad j \geq j_L$$

- The pension income is composed of the product of the contribution rate τ_t and the total income from work activities, divided by the number of pensioners:

$$e_t^{(j)} = \tau_t \frac{\omega_t L_t^s}{\sum_{j=0}^{j_{L-1}} N_t^{(j)}} \quad j < j_L.$$

Consumer's Behavior

- All individuals can consume their current wealth in the current period or transfer it to the next period by two investment opportunities:
  - Bonds are traded at time t at unit price and give in the next period $t + 1$ the return of R_t.
  - Shares are traded on the rates p_t and deliver in each period a stochastic dividend d_t.
- The wealth of a consumer is given as the sum of wage or pension income and the income from capital investment decisions of the previous period:

$$w_t^{(j)} := \begin{cases} e_t^{(j)}, & j = J \\ e_t^{(j)} + R_{t-1} y_{t-1}^{(j+1)} + x_{t-1}^{(j+1)} (p_t + d_t), & j = 0,1,...,J-1. \end{cases}$$

Consumer's Behavior

- For the consumer, there are different strategies for consumption, bond investment and share investment. Within the planning horizon a strategy has to fulfill the following conditions in each period:

$$c_0 = w_0$$

$$c_n + y_n + x_n p_n = \hat{e}_n + \hat{R}_{n-1} y_{n-1} + x_{n-1}(p_n + d_n) \quad n = 1,...,J.$$

- The goal of a consumer is to maximize the logarithmic utility function that reaches to the end of his life:

$$U^{(j)} = \ln(c_0) + \sum_{n=1}^{j} \beta^n \ln(c_n).$$

Firm‘s Behavior

- In each period t the firm uses its capital stock K_t and labor L_t to produce. The production process in the form of the production function is exposed to random environmental influences η_t

$$F(L_t, K_t, \eta_t) = \kappa\, L_t^{\alpha} K_t^{1-\alpha} + \eta_t, \quad \kappa > 0, \alpha \in]0,1[$$

- The time evolution of the capital stock is determined by the depreciation rate δ and the investment I:

$$K_{t+1} = I_t + (1-\delta)K_t.$$

- The entrepreneurial investment decision is financed only by issuing a number of bonds at unit price. The bonds that have been issued in period t in order to finance the investment decision, generate the obligation $R_t B_t$ in period $t + 1$.

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Firm‘s Behavior

- For the investment decision in period t, it is assumed that the dividend in the next period $t + 1$ should be maximized.

$$d_{t+1} = \frac{F(L_{t+1}, K_{t+1}, \eta_{t+1}) - \hat{\omega}_{t+1} L_{t+1} - R_t B_t}{\bar{x}}$$

- We get the optimal investment level:

$$I = \frac{1}{\gamma_1} \ln \left(\frac{(1-\alpha)\kappa}{\gamma_0 \gamma_1 R} \left(\frac{\alpha\kappa}{\hat{\omega}_{t+1}} \right)^{\frac{\alpha}{1-\alpha}} \right) K_t$$

- This results in the bond offer:

$$B = \frac{(1-\alpha)\kappa}{\gamma_1 R} \left(\frac{\alpha\kappa}{\hat{\omega}_{t+1}} \right)^{\frac{\alpha}{1-\alpha}} K_t$$

Calibration of the Model

- For life expectancy we use $J = 14$ and the retirement age is set to $j_L = 6$.
  - Consequently, always 15 generations live at the same time. Thereof nine go to work and six are retired.
  - Assuming that an individual consumes during 60 years (a childhood phase without consumption does not exist in the model), then a time step in the model corresponds to four years of life.
  - Any consumer who is not already in retirement, provides one unit to the labor market.
- Other parameters δ, α, κ, β, γ, η are taken from empirical studies.
- To assess which pension system is beneficial for the population, the lifetime welfare in the form of the following dimensionless variable is examined

$$U_t(\tau) = \sum_{j=0}^{J} \beta^{J-j} \ln c_{t-j}^{(j)}.$$

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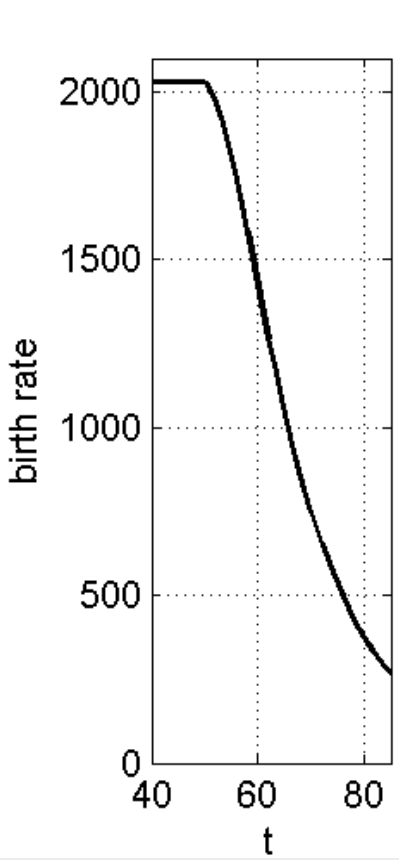
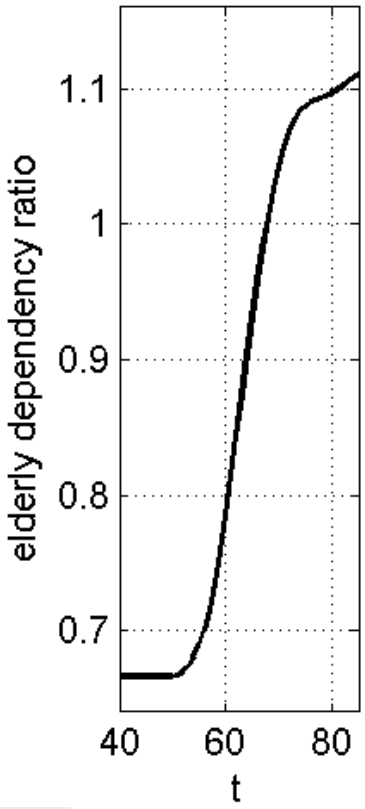
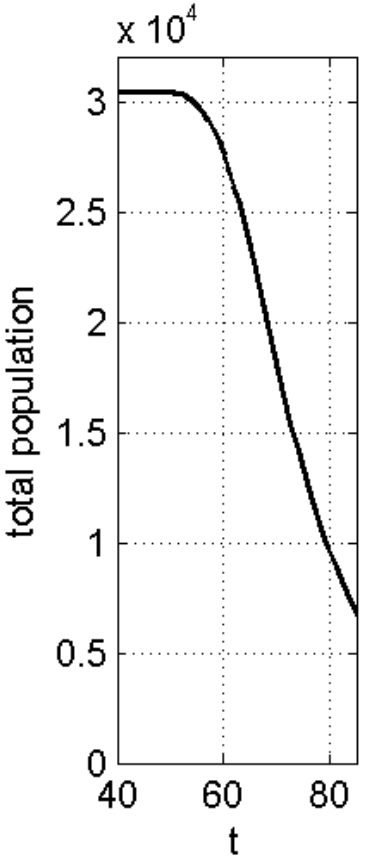
Population dynamics in the model

- For $t < 50$ the population is constant. This initial time phase is used to bring the model to its steady state. At $t = 50$ the onset of a demographic change is modeled by reducing the generation dependent birth rates.

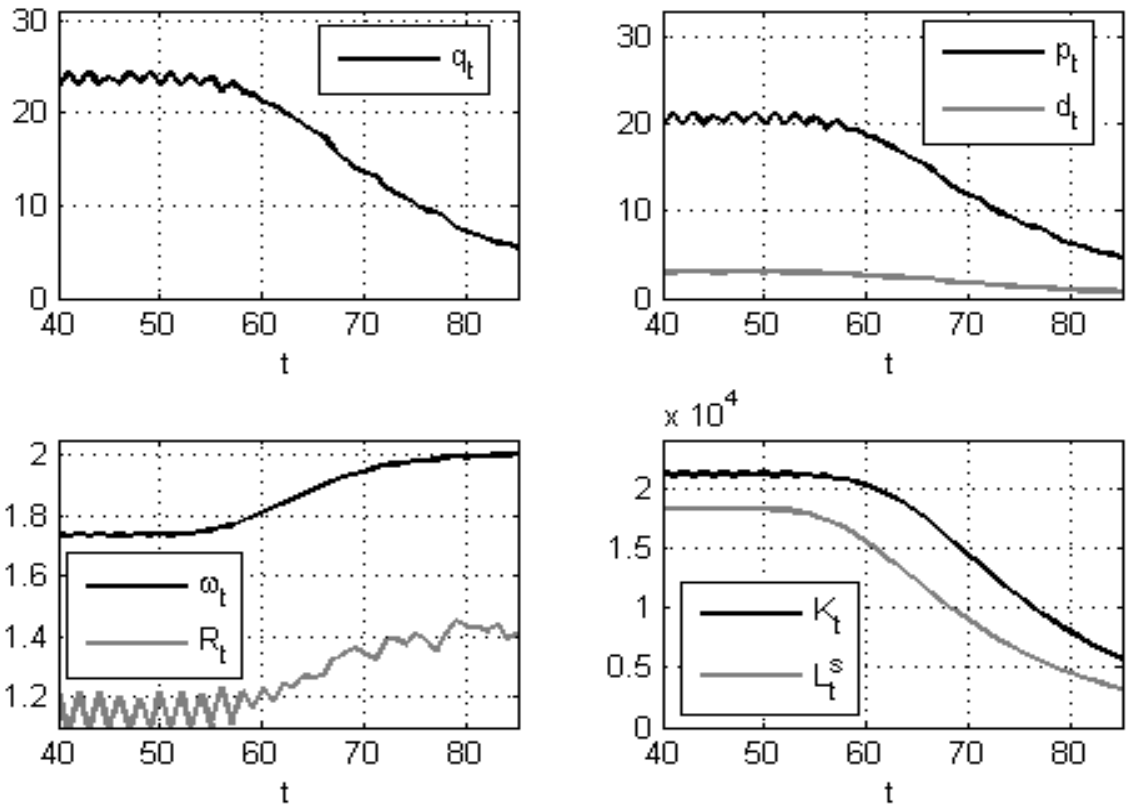






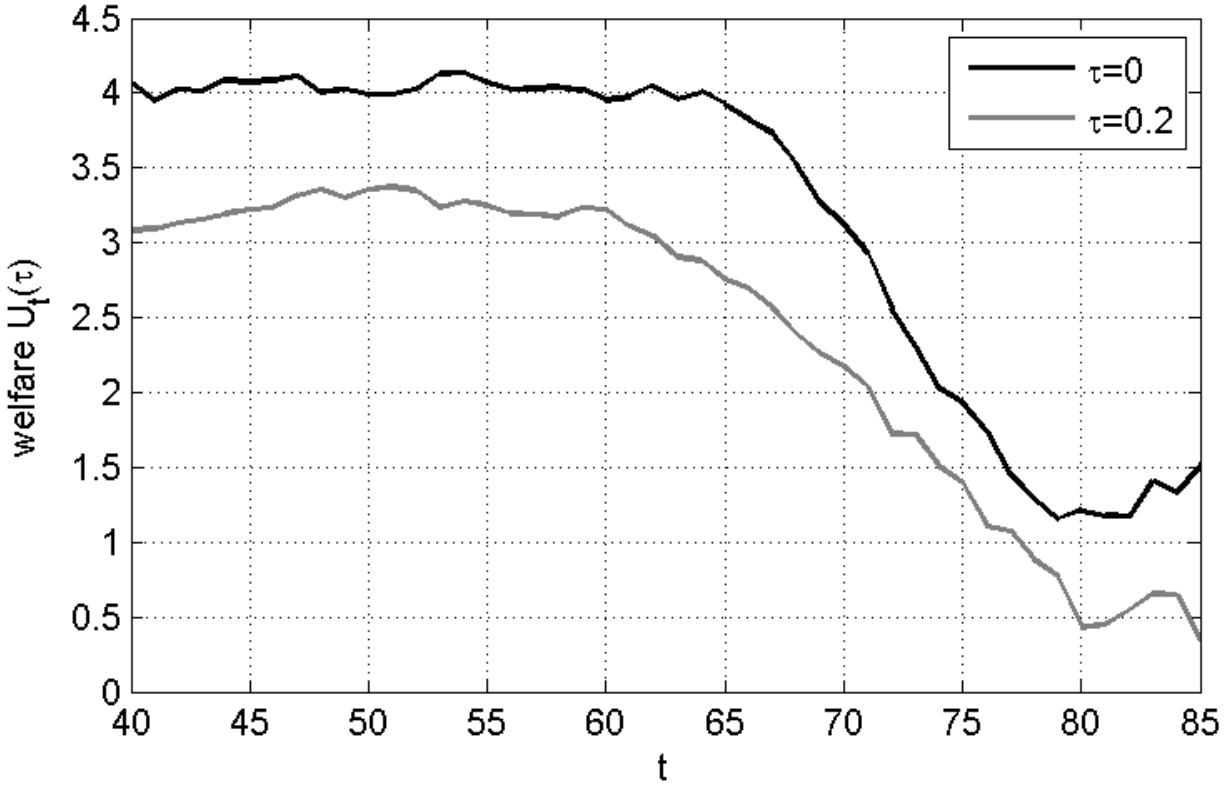
Parameter dynamics in presence of aging

- Most striking is the drastic decline in stock prices and capital stock.
  - This decline in stock prices is know as the phenomenon of "**asset market meltdown**" and has been predicted by several models.
- Wages are rising slightly due to the scarcity of the labor supply. Also the bond yield increases slightly.



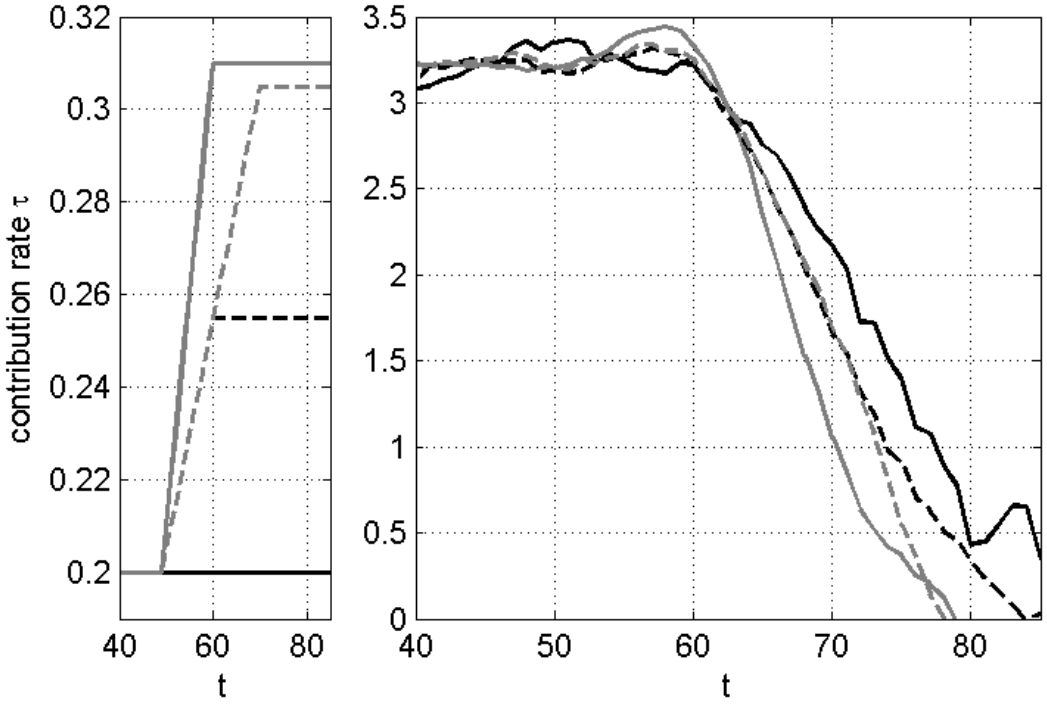
Welfare for constant contribution rate

- The impact on the welfare of consumers is shown as the average of three different realizations of the random process in the production function.



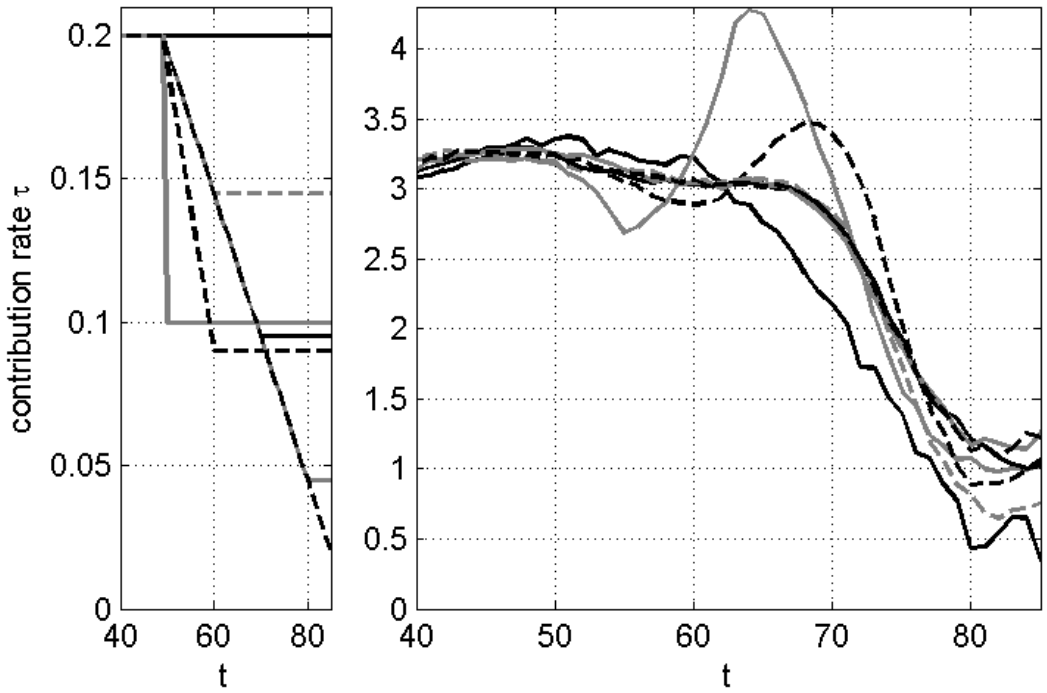
Welfare for increasing contribution rate

- After the onset of demographic change at $t = 50$ the level of welfare can be stabilized at first. The level is sometimes even higher than the ***reference curve*** ($\tau = 0.2 = \text{const}$).
- Starting at $t = 63$, all welfare curves with ***increasing contribution rates*** fall below the reference curve.
- An increase in the contribution rate is not an appropriate means of preventing or dampening the loss of welfare. The welfare loss is delayed at first but will be more severe later.



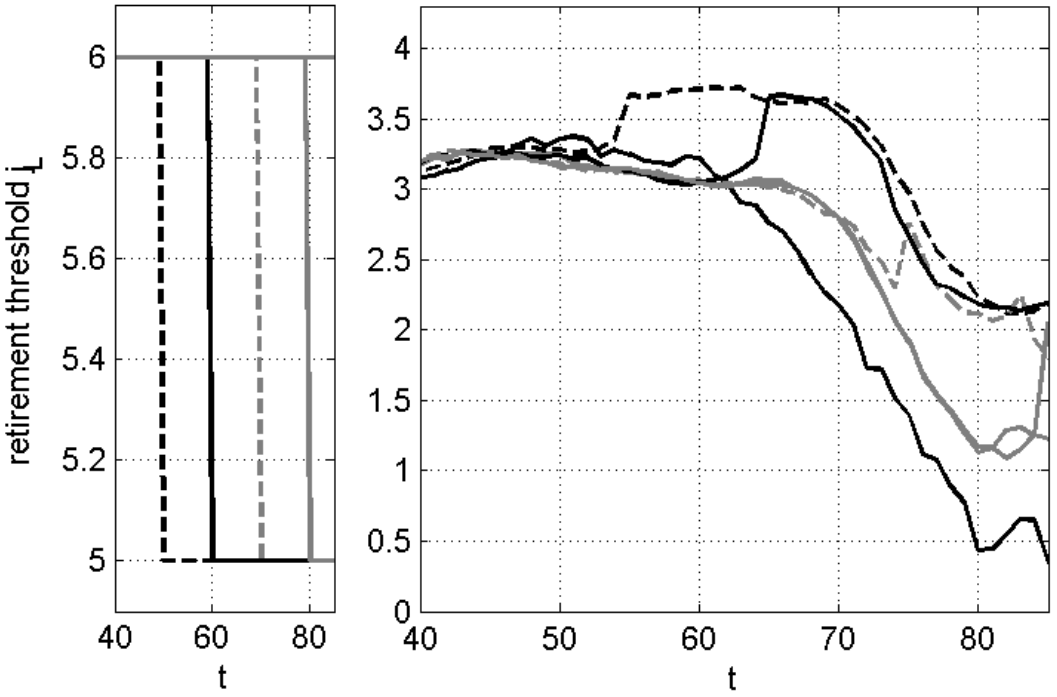
Welfare for decreasing contribution rate

- With a ***decreasing contribution rate***, a reduction of welfare occurs at $t = 50$. This is due to the fact that these generations suffer from reduced pensions, but could not benefit from the lower contribution rates during their working life.
- For all cases we find values for the welfare that lie after $t = 62$ permanently above the reference curve.
- A reduction in contributions can therefore not prevent the loss of welfare. But it is possible to reduce the strength and to shift in time the decline of welfare.



Welfare in case of raising the retirement age and decreasing contribution rate

- Raising of the retirement age from $j_L = 6$ to $j_L = 5$.
- In all cases the contribution rate is decreased linearly between $t = 50$ and $t = 89$ from $\tau = 0.2$ to $\tau = 0$.
- Compared to the scenarios with constant retirement age we find the possibility to reduce the decline of welfare.



Conclusion

- Demographic changes will affect the entire economy by affecting productivity, savings, consumption, interest rates and asset valuations.
- An increase of pension age at simultaneous lowering of the contributions and gradual abolition of the pay-as-you-go pension system proves to be the best possibility not to remove but to reduce the welfare loss due to demographic changes.
- A policy with increases in contributions as a consequence of the demographic change shows the heaviest welfare losses.
- Taken into account the recent pension reforms in Germany (increase of regular retirement age from 65 to 67, introduction of a sustainability factor to limit the increase of contribution), a stronger increase in the retirement age or a faster transition from a pay-as-you-go pension system to a capital funded one would make sense.
- But with an aging electorate, it is questionable whether such a policy will be enforceable.

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