The optimal mix of the first and second pension pillar*

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Abstract

Recently some policy proposals in the Netherlands consider a larger first pillar pension, possibly at the expense of the second pillar. This paper explores the optimal mix of first and second pillar pension schemes. Our simulation of several financial variables and Dutch demographics shows an intuitive trade-off. On the one hand, first pillar pensions are less volatile than second pillar pensions, as population growth is less uncertain than financial market returns. On the other hand, demographic risk is not negligible at longer horizons and the median return of the first pillar is lower. To deal with risks stemming from demography and asset markets, diversification effects suggest that a mix of first and second pillar pensions is socially optimal. An increase in life expectancy has a more immediate effect on second pillar benefits, but has also an effect on first-pillar replacement rates in the medium and long run.

Introduction

The optimal mix of pay-as-you-go (PAYGO) and funded elements in pension systems is a hot topic in many countries. In light of the current low interest rates, some policy proposals in the Netherlands consider to expand the PAYGO (first) pillar, possibly at the expense of the relatively large Dutch funded (second) pillar.[1] In the US, proponents to privatize social security, i.e., a larger second pillar, argue that the rate of return in a funded scheme is larger than that of the largely PAYGO financed social security. In all developed countries, population ageing fuels calls for more pre-funded old-age provisions (OECD Pensions Outlook, 2014).

It is not straightforward which mix of the two pillars is most beneficial for society. A larger first pillar is beneficial when capital returns are low and population growth and productivity growth are high. However, the second pillar becomes more beneficial when population growth and productivity growth are low. In a simulation study, we examine how differences in the pillar mix affect the level and riskiness of benefits. The simulation setup is closer to the real-world Dutch economy than calibrated stylized models encountered in the literature (Teulings and De Vries, 2006; Bovenberg et al, 2007; Campbell and Nosbusch, 2007; Gollier, 2008; Cui, De Jong and Ponds, 2011; Knell, 2010; Mehlkopf, 2011).

Our simulation of several financial variables and Dutch demographics indicates an intuitive trade-off. On the one hand, first pillar pensions are less volatile than second pillar pensions, as population growth and productivity growth are less uncertain than financial market returns. On the other hand, demographic risk is not negligible at longer horizons and the expected return of the first pillar is lower. Theoretically, to deal with risks stemming from demography and asset markets,

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1 https://fd.nl/economie-politiek/1145655/we-moeten-pensioen-meer-via-omslagstelsel-gaan-regelen

diversification effects suggest that a mix of first and second pillar pensions is socially optimal. Our results support this argument. In the low tail of the probability distribution of replacement rates, the lower uncertainty and diversification afforded by a PAYGO component compensates for the lower expected return from a smaller funded part. A transition to a more PAYGO-oriented system, by shifting contributions from the second to the first pillar – akin to the aforementioned policy proposal for the Netherlands - leads to higher benefits in the short run, but a substantially lower return in the long run. Thus, a transition from a 50-50 mix towards a larger first pillar is only warranted at high levels of risk aversion.

We perform two impulse response analyses to show how different mixes respond to a permanent change in financial returns or mortality probabilities. A hybrid pillar system does not make benefits much less risky following a permanent decrease in financial market returns. An increase in life expectancy has a more immediate impact on second pillar benefits, because the funding ratio in the second pillar reacts quicker to such an increase than the old-age dependency ratio, which drives the generosity of the first pillar. In the long run, population ageing has a similar effect on the first pillar, however.

Literature

The present paper connects to several strands of literature. The first strand considers the welfare gains of PAYGO and funded pension systems. Krueger and Kubler (2006) find that the US PAYGO system for social security does not result in an ex ante Pareto improvement. While the system facilitates intergenerational risk sharing by insulating the old from volatile capital markets, it depresses savings and capital accumulation. The lower capital stock in turn decreases future wages, which makes a large number of cohorts worse off. Sánchez-Marcos and Sánchez-Martín (2006) also find that this general equilibrium effect quantitatively dominates the benefits from improved risk sharing. Thus, the added value of PAYGO pensions is limited in their model.

Whereas the above-mentioned papers focus on the negative impact of a PAYGO system on capital market returns, Matsen and Thøgersen (2004) argue that a PAYGO system can be viewed as an asset whose implicit return equals the growth of the wage bill, and that some exposure to this asset can be welfare-enhancing if the correlation between its return and the stock market return is not too high. Nishiyama and Smetters (2007) find that more prefunding results in a Hicksian efficiency loss when individuals cannot insure against idiosyncratic wage shocks in the market.

Second, a number of papers quantify the welfare gains from intergenerational risk sharing in funded pension schemes (Teulings and De Vries, 2006; Bovenberg et al, 2007; Gollier, 2008; Cui, De Jong and Ponds, 2011; Mehlkopf, 2011; Lever and Michielsen, 2016). Potential gains arise from the exposure to stock returns obtained before individuals join a pension fund. Empirical estimates of these gains in terms of certainty-equivalent of pension benefits range from close to zero (Mehlkopf, 2011) to 25% (Gollier, 2008).

The estimated welfare gains are sensitive to whether labour supply is exogenous to the ad-interim performance of the pension fund, the correlation between wage growth and stock market returns and how much stock market risk generations can assume before they are born. Funded pension systems have limited ability for intergenerational risk sharing if younger workers cannot be forced to join the pension system after negative shocks (Mehlkopf, 2011; Beetsma, Romp and Vos, 2013). The welfare gains depend positively on the equity premium and show an inverted V-shape in risk perception: If individuals are very risk-tolerant, the time diversification of stock exposure before birth is of limited added value, whereas very risk-averse individuals would not want to hold stocks at all, even if they can extend their investment horizon through a funded pension scheme.

Integrating the insights from the welfare gains of the two systems, a small literature deals with the optimal relative sizes of PAYGO and funded pension pillars. Beetsma and Bovenberg (2009) and Beetsma, Romp and Vos (2013) study an overlapping generations model with wage and depreciation risk. The second paper adds endogenous labor supply to the first paper. Both models are two-period models with a constant size of generations, which may miss demographic risk. A multi-pillar pension system can implement the social optimum by having a defined-benefit second pillar so that the young can share in the old's equity risk, and by linking either the first- or second-pillar benefits to wages so that the old share in the young's wage risk. With endogenous labour supply, the optimal money's-worth-ratio of marginal contributions equals one for both pillars so as not to distort labour supply.

Campbell and Nosbusch (2007) look at the optimal design of a PAYGO system in general equilibrium when physical capital is in fixed supply. The laissez-faire outcome optimally shares wage risks between generations, since the old generation is exposed to wage risk through the price they receive for selling their physical assets to the young. A PAYGO system with benefits that depend on capital returns – mimicking the properties of a funded pillar - can also share capital risk optimally between generations. Another paper that considers physical assets in fixed supply is Knell (2013). When the funded pension pillar mostly invests in assets in fixed supply such as land or gold, the incidence of demographic shocks is largely the same in funded and DC PAYGO systems: in both systems, small cohorts are better off - either because they can buy/sell the physical asset at low/high prices in a funded system, or because they receive high benefits per capita in a DC PAYGO system.

Knell (2010) studies the optimal relative size of the two pillars in an OLG model when individuals care about relative consumption vis-à-vis other contemporaneous cohorts. The optimal size of the defined-contribution PAYGO pillar increases in the relative utility weight of the consumption of the old. The PAYGO pillar reduces consumption inequality by making the old's consumption dependent on the young's wages.

Instead of determining the optimal mix of the two pillars from a theoretical model, Bohn (2009) looks at stylized real-world pension policies and asks if it can be rationalized by calibrated standard preference structures. Under constant relative risk aversion, real-world systems have a suboptimal low productivity risk exposure for the elderly. The observed safe transfers to retirees can be better explained by age-declining risk tolerance such as habit formation.

The paper of Auerbach and Lee (2011) presents a comparison of PAYGO systems based on the existing systems in Sweden, the US and Germany. Comparing the three systems, shocks are best smoothed in the non-funded Swedish NDC system. Nonetheless, in terms of social welfare, the lower average rate of return more than offsets the benefits of risk reduction. The differences between the systems may disappear when transition generations are taken into account.

A third stream of literature concerns the transition from PAYGO to funded systems in response to population ageing. According to Sinn (2000), such a transition does not result in welfare gains but is merely a zero-sum redistribution between generations. Efficiency gains of funded systems, e.g., more capital accumulation, can also be achieved with policies outside the pension domain, such as investment subsidies.

Miles and Černý (2006) simulate a calibrated model of the Japanese welfare system to determine the welfare effects of a reform that reduces the generosity of the PAYGO system. The reform generates a potential Pareto improvement but there are nontrivial losses for early generations. A less generous PAYGO system increases aggregate savings and decreases the risky asset share of private savings. An important part of the long-run welfare gain of a less generous PAYGO system stems from allowing individuals to delay pension savings, provided participation in a funded pension system is voluntary. This is particularly valuable when young individuals are credit-constrained.

Ludwig and Reiter (2010) perform a similar exercise for the German pension system. They determine the generational welfare weights that rationalize the current arrangements, and ask how a social planner would respond to a fertility shock. Their social planner would reduce per-capita benefits, as the labour market distortions from higher PAYGO contributions are severe. Kitao (2014) compares four options to restore the sustainability of US social security given projected demographic trends: an increase in payroll taxes, lower benefits, a higher pension age and means-tested benefits. Compared to a decrease in benefits or a higher pension age, increasing wage taxes decreases labour supply and savings, and means-testing the benefits even more so since the means-test constitutes an additional disincentive to accumulate private wealth.

Lastly, a group of papers looks at the political sustainability of PAYGO and funded pension systems. Political support for PAYGO systems from the elderly is stronger than opposition against it from younger cohorts (Cooley and Soares, 1999; Gonzalez-Eiras and Niepelt, 2008; D'Amato and Galasso, 2010). Two main reasons dampen the young's resistance to the PAYGO system. The young treat their past contributions to the PAYGO system as sunk, so they evaluate the PAYGO system more favourably than suggested by the implicit return on their current contributions. Secondly, the young can shift part of the costs of the PAYGO system to future generations because it lowers aggregate savings, which increases the young's return on capital.

Intragenerational inequality further increases support for the PAYGO system (Song, 2011). Particularly poor individuals are disinclined to save because of the intragenerational redistribution through PAYGO pensions. The increase in inequality due to differences in savings increases in turn the political support for an even more extensive PAYGO system.

Methodology and data

We evaluate the pension result (first-pillar plus second-pillar benefits) for different pension systems. Each system is a mix of first- and second-pillar pensions. We look at the boundary cases where the system is fully PAYGO or fully funded, as well as a few weighted combinations.

The funded system we consider is a collective defined contribution fund, which shares equity risk, interest rate risk and demographic risk among current and future generations. We calculate a funding ratio that is defined as the assets over the nominal present value of the fund's liabilities where the liabilities are discounted using the nominal term structure. Each year, the claim of any worker or retiree is adjusted by one tenth of the difference between the current funding ratio and 100%. The funded pension scheme invests half of its assets in equities and the other half in bonds, whose maturity matches that of the liabilities. We subtract a yearly portfolio cost of 0.5%. The best estimates of survival probabilities are adjusted each year with Bayesian updating.

To compare the first-pillar-only and the second-pillar-only mix, we consider the Aaron-Samuelson rule which states that return on the first pillar equals the growth of the wage sum while the return on the second pillar equals the return on investments. This gives an indication for the expected return on both pillar-only mixes. It does not say anything about uncertainty. The simulation study enables us to evaluate the impact of the different risk sources on the pillar mixes.

We simulate each considered mix for 2000 scenarios. The scenarios are generated with the model in Muns (2015). The scenarios have different annual time series for demographics (birth, and mortality), financial markets (equity returns, interest rates, inflation rates) and wages. Though the time series are simulated using different submodels, each time series starts with the end-of-year value in 2016 and ends in 2115. Initial rights in the second pillar are determined using the term structure of end-2015.

The mortality model is based on the mortality of a group of Western European countries (Lee and Li (2005)). The data runs from 1960 to 2013, and is from the Human Mortality Database if available, otherwise from Eurostat. We adjust the otherwise low uncertainty in mortality rates to the somewhat larger uncertainty of the United Nations' World Prospects (UN (2015)). The fertility model is similar to the model in Lee and Tuljapurkar (1994). This model is estimated using data from Statistics Netherlands over the period from 1960 to 2014. The financial model is from the term structure model in Koijen, Nijman, and Werker (2010). The financial time series are from Bloomberg and Datastream and run from 1973 to 2014. More details on this dataset are in Van den Goorbergh, Steenbeek and Vlaar (2011). The time series for the wages depend on the productivity rate in the Netherlands as well as in an international set of countries. The productivity growth data is from the OECD series GDP per hour worked at constant prices. All data has an annual frequency, except for the financial model which has a quarterly frequency. The submodels are subject to certain restrictions, such as a long-run mean, see Muns (2015) for details. The model allows for contemporaneous dependence between the annual shocks in the different submodels. However, this dependence turns out to be low which indicates diversification benefits between the first and the second pillar.

We abstract from intragenerational differences in income and the working period by considering a representative agent for all individuals. First, we assume that all individuals live their entire life in the Netherlands. Therefore, we disregard the effects of migration since particularly migrants from developing countries have lower PAYGO benefits during their pension period. Second, individuals have a similar working career with the same pension configuration during their career. Conditional on survival, individuals start to work at the age of 25, retire at 70, and have a maximum age of 120.

Each individual works full time, and all individuals earn the same wage in a specific year. This helps us to isolate the effect of different configurations of the pension system.

A constant pension age differs from the current Dutch pension system where the pension age increases with the same number of months as life-expectancy increases. We believe that this would not have a substantial effect on our results. Both first and second pillar pensions become cheaper when the pension age increases. This effect could be somewhat stronger for the second pillar where the compound interest has a convex effect on the cumulative return on investments during the working ages.

Since the Netherlands is a small open economy, we restrict ourselves to partial equilibrium effects. Thus, capital markets do not respond to a change in investments after an adjustment of the pillar mix. In addition, while pension premiums are fixed and thus allowed to be distortionary in the labor market, we assume that an adjustment of labor-related pension accrual rates does not affect the incentive to work for our representative agent. The long-run focus of our analysis means that (i) historic accrued pension benefits are adjusted to the considered mix, and (ii) transition effects are not considered. As a robustness check of (i), we initialize the historic accrued benefits at 50-50 for each considered mix.

We fix the pension premium per capita for all mixes between PAYGO and funded pillars. That is, the total contribution rate to both pillars equals 17.24% of the wage irrespective of the relative size of the two pillars.[2] In the PAYGO system, the benefits per capita are inversely proportional to the old-age dependency ratio since the contribution rate is fixed.

As the population ages, the PAYGO benefits become less generous for the retired generation. Ageing of the population can be due to a reduction in childbirth and (net) immigration or to an increase in life expectancy. The funded pillar is not sensitive to changes in childbirth and immigration. However, the annuity that can eventually be financed from the same contributions – given financial market returns – decreases if life expectancy increases. Anticipated changes in life expectancy immediately affect the funding ratio, and thereby the benefits of retirees. The PAYGO pillar is isolated from financial market risk.

Though PAYGO-tilted mixes are sensitive to changes in the old-age dependency ratio, this ratio only changes gradually after an unanticipated shock to mortality probabilities. In funded-oriented pension systems, replacement rates adjust faster in case life expectancy increases. Our simulations can shed light on the adjustment speed and long-run impact in both pillars.

For each birth cohort, the different mixes are evaluated by the replacement rates in different scenarios. One welfare measure of a certain cohort is the CRRA utility function with replacement rates $r = \{r_0, r_1, r_2, \ldots\}$, risk aversion parameter γ and discount factor β,

$$U(r;\beta,\gamma) = \sum_{t=0}^{\infty} P[\text{alive and pensioned in } t]\, \beta^t \, \frac{r_t^{1-\gamma} - 1}{1-\gamma}$$

[2] With a 50-50 mix of the two pillars, the median per-capita first-pillar contribution in 2015 then amounts to 3212 euro. The first-pillar expenditures in the Netherlands in 2015 (35.8 billion euros, Statline link) divided by the population between 18 and 65 (10.7 mln, Statline link) equaled 3360 euro per capita.

Throughout the paper we use $\beta = 0.98$. Another welfare measure for a certain cohort is some percentile *p* of the average replacement rate $V(r)$

$$V(r) = \frac{\sum_{t=0}^{\infty} P[\text{alive and pensioned in period } t] r_t}{E[\text{life expectancy given age} = 70]}$$

The latter performance measure does not rely on parameters γ and β. Since it does rely on the chosen percentile *p*, it cannot measure the risk-return trade-off inherent in a choice between first and second pillar pensions.

After our benchmark simulations, we also perform two impulse response analyses. In the first, we decrease all future mortality rates such that the time path of the period life expectancy corresponds to the 95$^{\text{th}}$ quantile best scenario of the Statistics Netherlands 2014 forecast. This means that the shock is such that the resulting life expectancy is at the 5% highest percentile of the distribution of life expectancy. To recover the change in the mortality rate *m*(*x*), we find for each simulation period *t* the adjustment a_t in the survival function that gives the corresponding lower bound $LE_t^{95\%}$ of the life expectancy,

$$E[\tilde{X}] = \sum_{y=0}^{\infty} P(X > y)^{(1+a_t)} = LE_t^{95\%} \quad P(X > y)^{(1+a_t)} = \exp\left(-\int_{x=0}^{y} (1 + a_t) m(x)\, \mathrm{d}x\right).$$

The solid line in Figure 1 indicates the adjustment a_t that we apply to the mortality rate scenarios. The adjustment is more pronounced for more distant years since the confidence bands of the life expectancy forecast are wider.

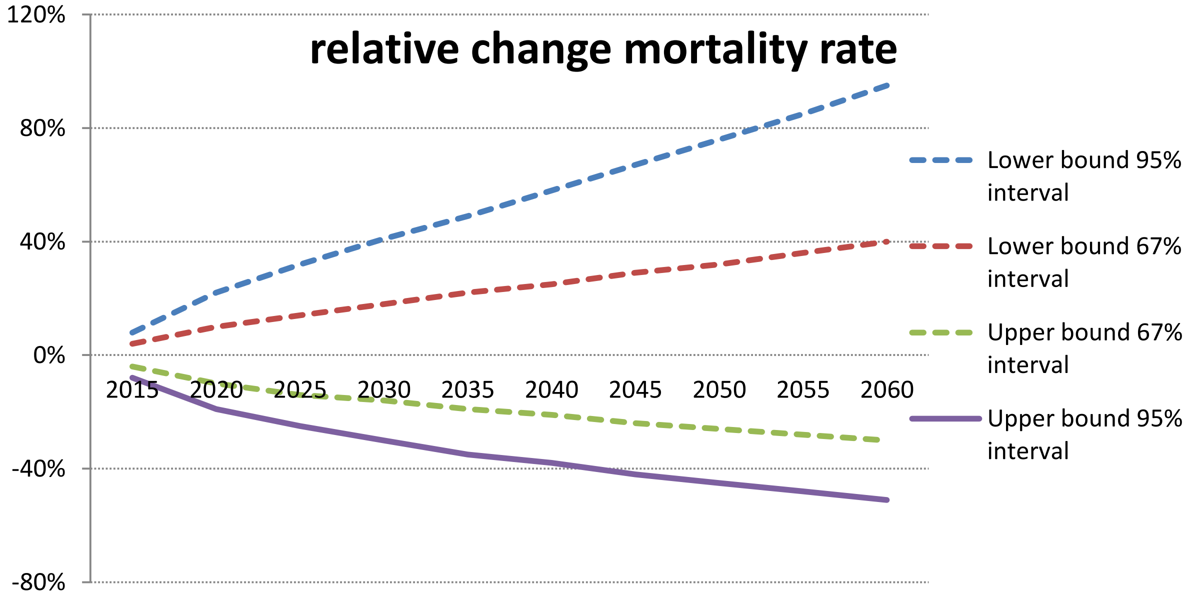

Figure 1: 67 and 95%-confidence intervals of relative changes in Dutch mortality rates per year. Source: Statistics Netherlands, forecast 2014.

Secondly, we conduct an impulse response analysis in which we permanently lower the equity premium from the first simulation year onwards. In a full PAYGO system, this should not affect the replacement rates since PAYGO pension benefits are insensitive to equity returns.

Results

As a first indication, we consider the outcome of the Aaron-Samuelson rule. We use continuously compounded returns per annum, which takes compounding of returns into account. For the return in the first pillar, notice first that the wage growth is 3.3%. Second, the dependency ratio increases from 0.4 in 2040 to 0.55 in 2115 (see Appendix). This indicates a long-run increase in the dependency ratio of $\left(\frac{0.55-0.4}{0.4}\right)^{1/75} = 0.4\%$ per year. Hence, the real return (in excess of the wage growth) on first pillar contributions is about -0.5% per year (3.3% – 0.4% – 3.3%).

In the second pillar, we assume the average return on stocks and bonds is 5.5% and 3.6%, respectively.[3] Portfolio costs are 0.5%. In our system, a higher life expectancy has a downward effect on second pillar pensions as the pension period becomes longer while the length of the accrual period remains the same. In a median scenario, the pension period increases from 11 to 23 during the next 100 years (Figure 7 in Appendix). The longer pension period makes pensions more expensive. The longer pension period has a downward impact on pensions of $(23/11)^{1/100} - 1 = 0.74\%$ per year. The investment horizon in this collective scheme increases each year with (23 – 11)/100 = 0.12 yr. This raises the nominal 2nd pillar return with $(1 + 4.55\% - 0.5\%)^{0.12} - 1 = 0.5\%/\mathrm{yr}$. Thus, the real return (in excess of the wage growth) on second pillar contributions is about 0.5% per year (½(5.5% + 3.6%) – 0.5% + 0.5% – 0.74% – 3.3%).

Comparing the returns of both pillars we conclude that the mean return on the second pillar exceeds the return on the first pillar. Rather than this single measure with real world probabilities, our outcome of primary interest is the whole probability distribution of the replacement rate. The lagged response of first pillar returns to an unanticipated mortality shock indicates that diversification benefits depend on the correlation between historic cumulative shocks to mortality (first pillar) and instantaneous shocks to mortality and cumulative shocks to financial returns (second pillar). As a consequence, a mix of both pillars may result in a less volatile replacement rate.

Figure 2 presents the results for the measure $U(r; 0.98, \gamma)$. Older cohorts tend to prefer a larger portion of second pillar pension in their mix since it provides a higher return. However, when uncertainty grows, they might prefer the certainty of a first pillar-only pension. As cohorts born before 1950 are already retired at the start of the simulation, they do not have to pay for the higher first pillar. Nevertheless, the oldest cohorts in Figure 2 prefer a larger second pillar because the initialization with an upward sloping term structure favors more historic accruals and demographics

[3] We conduct a robustness check with lower average returns.

are very unfavorable the next two decades (Figure 7

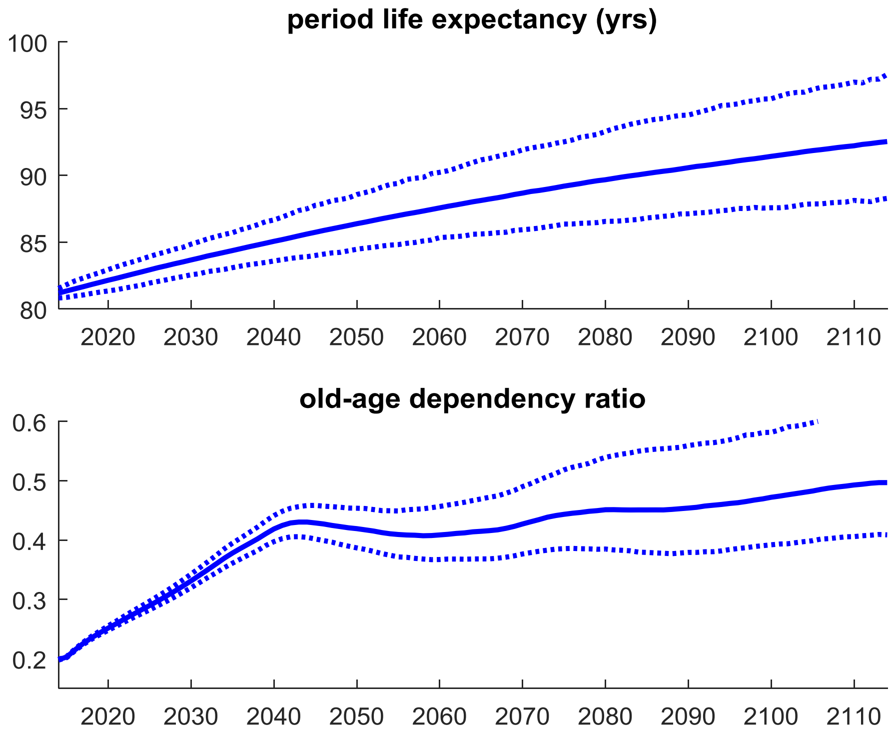

Figure 7 in the Appendix). The youngest cohorts prefer a mix of both pillars to benefit from the diversification effect of both pillars (Madsen and Thøgersen (2004)). A larger first pillar is preferred in case of more risk aversion.

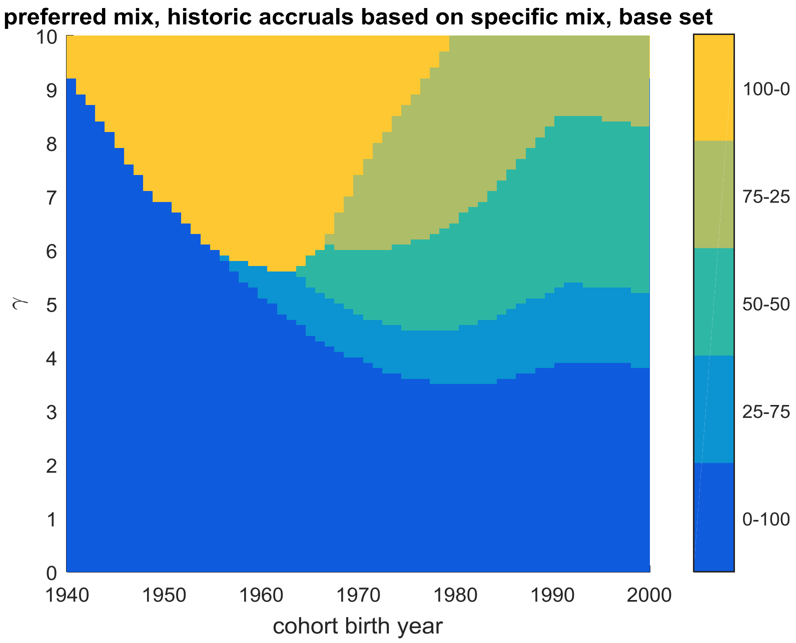

Figure 2: Preferred mix by cohort for different levels of risk aversion γ. Mix $m_1 - m_2$ indicates a share m_1 and m_2 of contributions to first and second pillar, respectively. Preferences based on U(r, 0.98, γ). Initial rights based on the considered mix.

The median of the replacement rate ($V(r)$) is informative of the expected pension that can be reached for each mix of PAYGO and funded pillars. In addition, high and low percentiles of the replacement rate $V(r)$ offer important insights in the riskiness of the pension benefits. Figure 3 shows that not only the median of the replacement rate, but also the percentiles above the 5th percentile increase in the relative weight of the second pillar. Though financial market uncertainty is larger than demographic uncertainty, this effect on the percentiles above 5% is outweighed by the higher expected return on the second pillar (the financial market return) than on the first pillar (the growth of the wage bill). In the deep tails of the probability distribution of $V(r)$ (the first percentile) do first-pillar pensions show a better result for young cohorts, see Table 1 and Table 2.

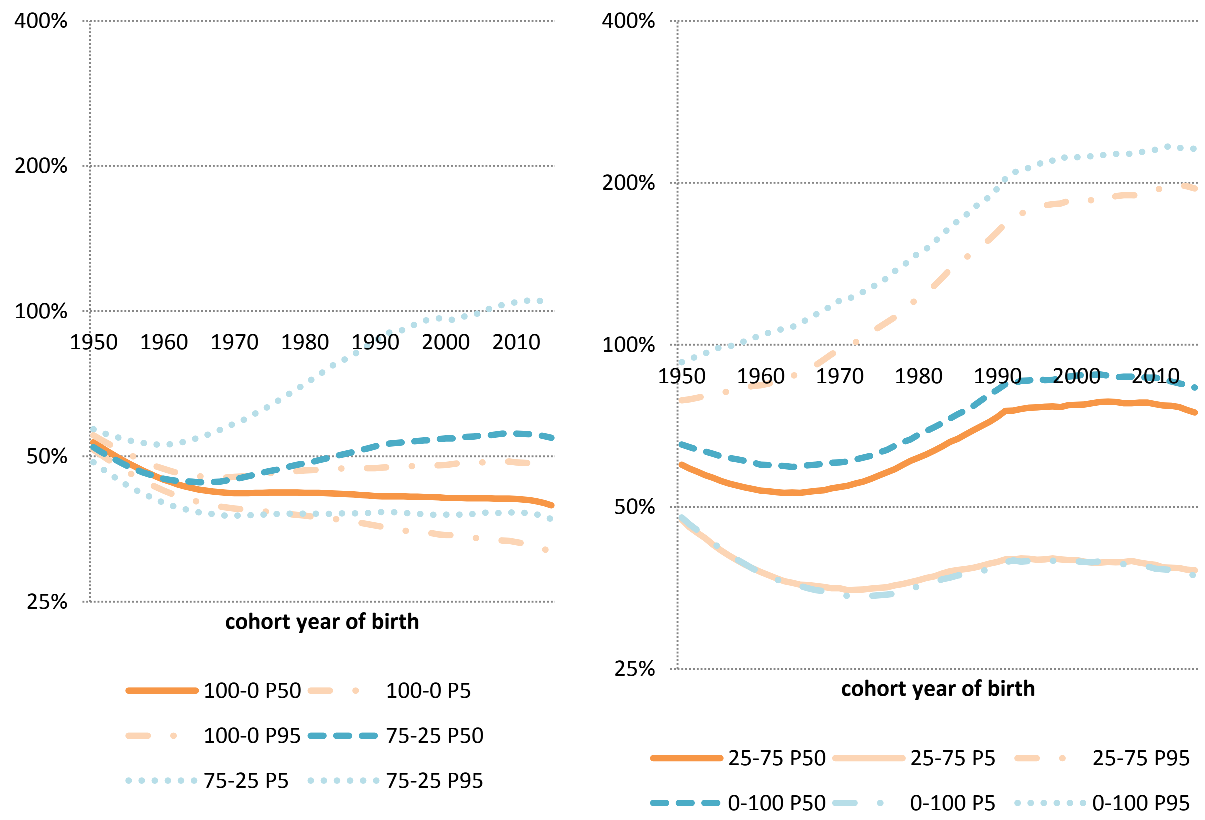

Figure 3: Replacement rates (median and 95% confidence interval of $V(r)$) per birth cohort for different combinations of the first and second pillar. The first number in the legend indicates the relative weight of the first pillar in the mix. Initial rights based on the considered mix.

Birth cohort 1992	100-0	75-25	50-50	25-75	0-100
Median	41.3%	53.1%	65.3%	75.5%	84.7%
P95	47.5%	90.3%	132.7%	172.2%	208.5%
P5	35.4%	38.3%	39.5%	40.0%	39.7%
P1	33.1%	35.0%	34.5%	32.8%	30.9%

Table 1: Percentiles of replacement rates for birth cohort 1992 with different mixes of first and second pillar. Mix $m_1 - m_2$ indicates a share m_1 and m_2 of contributions to first and second pillar, respectively. Initial rights based on the considered mix.

Birth cohort 1942	100-0	75-25	50-50	25-75	0-100
Median	61.4%	60.2%	62.4%	65.6%	69.3%
P95	62.9%	63.5%	69.8%	77.8%	86.3%
P5	59.9%	57.5%	56.8%	56.7%	56.9%
P1	59.4%	56.6%	54.9%	54.1%	53.5%

Table 2: Percentiles of replacement rates for birth cohort 1942 with different mixes of first and second pillar. Mix m_1 – m_2 indicates a share m1 and m2 of contributions to first and second pillar, respectively. Initial rights based on the considered mix.

The mortality impulse response analysis shows that first-pillar oriented systems are more vulnerable in the long run to an increase in life expectancy. For younger cohorts, the relative distance between the median pensions is greater in the left panel of Figure 4 (log scales) than in the right panel.

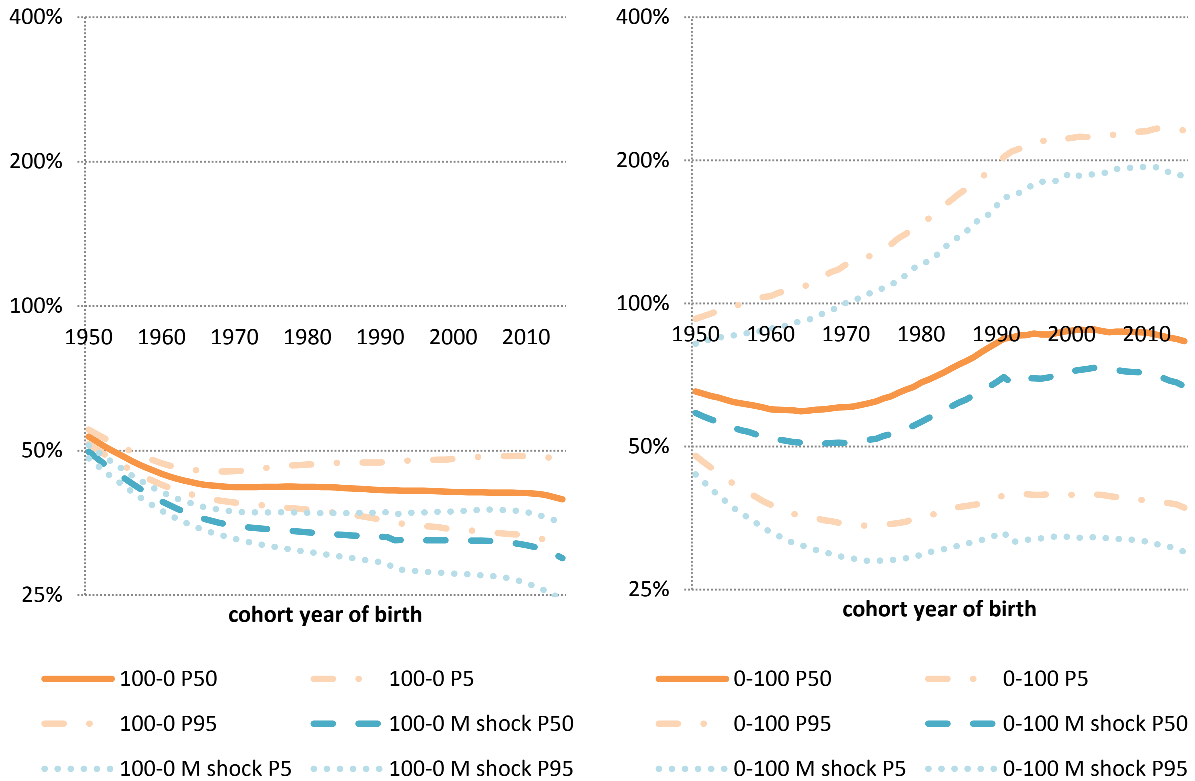

Figure 4: Replacement rates (median and 95% confidence interval) per birth cohort for first and second pillar, with and without a permanent shock to mortality probabilities. Mix m_1 – m_2 indicates a share m_1 and m_2 of contributions to first and second pillar, respectively. Initial rights based on the considered mix.

In the short run, second-pillar pensions are more affected. This contrast is also visible in Table 3 and Table 4, which show how the demographic shock differently affects a cohort that is at the beginning of its career and a retired cohort, respectively. The cohort born in 1942 is not really hit in a first-pillar scheme; both because the relative magnitude of the mortality shock is small initially and increases over time (see Figure 1) and since it takes some time for the increased life expectancy to manifest itself in the old-age dependency ratio.

In the second-pillar scheme, the increased life expectancy of working-age cohorts depresses the funding ratio immediately after the shock (from 100% to 87%). The accrued rights of these working-age cohorts are suddenly much more costly. As a result, retirees face gradually increasing benefit cuts.

Birth cohort 1992	100-0	100-0 M shock	50-50	50-50 M shock	0-100	0-100 M shock
Median	41.3%	32.5%	65.3%	52.0%	84.7%	68.1%
P95	47.5%	36.9%	132.7%	109.9%	208.5%	168.5%
P5	35.4%	28.3%	39.5%	31.5%	39.7%	31.5%
P1	33.1%	26.6%	34.5%	27.5%	30.9%	24.0%

Table 3: Percentiles of replacement rates for birth cohort 1992 for different mixes of first and second pillar, with and without a permanent shock to mortality rates. Mix $m_1 - m_2$ indicates a share m_1 and m_2 of contributions to first and second pillar, respectively. Initial rights based on the considered mix.

Birth cohort 1942	100-0	100-0 M shock	50-50	50-50 M shock	0-100	0-100 M shock
Median	61.4%	59.0%	62.4%	59.3%	69.3%	64.5%
P95	62.9%	60.3%	69.8%	65.9%	86.3%	79.2%
P5	59.9%	57.7%	56.8%	54.3%	56.9%	53.7%
P1	59.4%	57.2%	54.9%	52.6%	53.5%	50.3%

Table 4: Percentiles of replacement rates for birth cohort 1942 for different mixes of first and second pillar, with and without a permanent shock to mortality rates. Mix $m_1 - m_2$ indicates a share m_1 and m_2 of contributions to first and second pillar, respectively. Initial rights based on the considered mix.

Table 5 and Table 6 report that a permanent shock to the equity premium has no effect on a full PAYGO-system, as expected. Cumulated over a 45-year working period and part of the retirement period, small changes in the equity premium can have large effects. In a fully funded scheme, a participant at the start of its career experiences a 16% decrease in the replacement rate following a permanent decrease in the equity premium of 1% (Table 5).

Retired cohorts are much less affected than younger cohorts (Table 6). Because of the gradual adjustment to shocks and intergenerational risk sharing, the permanent shock to equity returns does not immediately translate fully into benefit cuts. The benefit adjustments become more substantial only when a significant fraction of the initially retired cohorts is already deceased.

Within each scenario, the 50-50 mix experiences half of the equity shock that a 0-100 mix experiences. After the equity shock, the median and bad-weather outcomes for the 50-50 mix are more driven by scenarios with a high life expectancy. As a result, the difference in median outcomes between the benchmark and impulse response is for the young cohort only about 28% lower for a 50-50 mix than for a second-pillar-only mix. Hence, diversification benefits are less than in the case where the returns on both pillars are independent from each other.

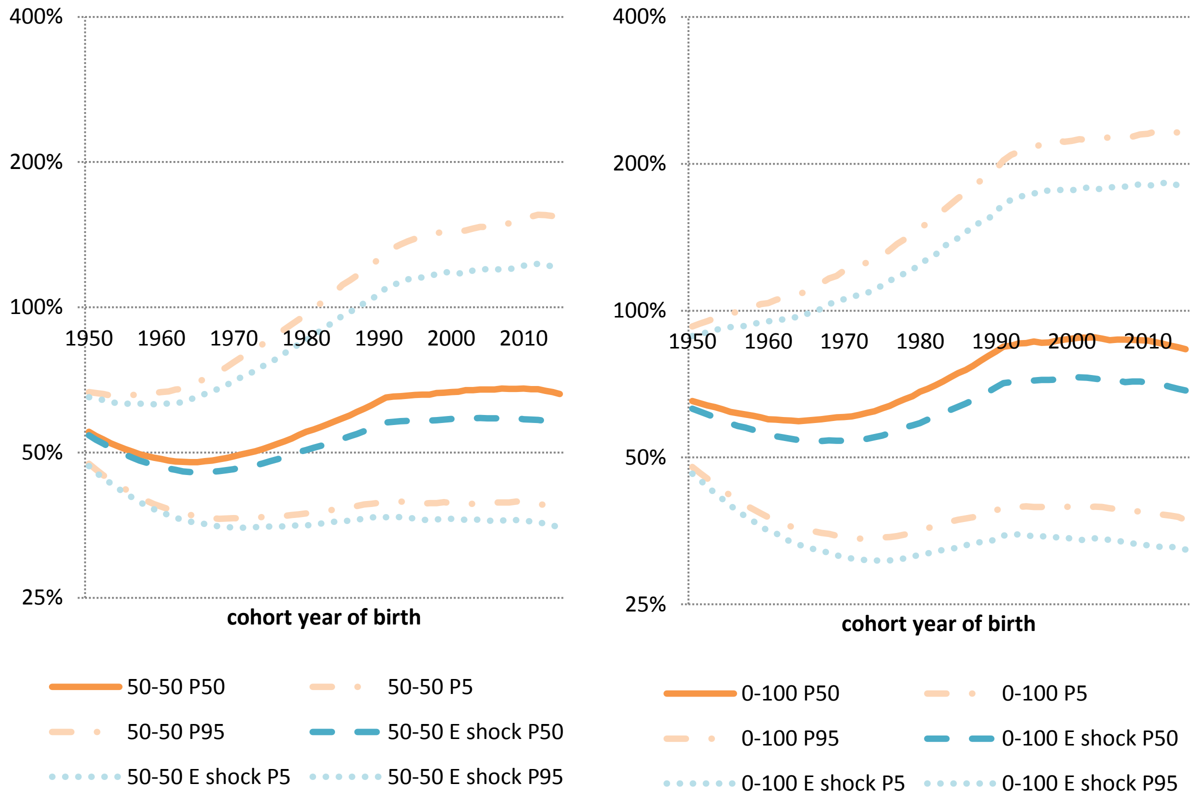

Figure 5: Replacement rates (median and 95% confidence interval) per birth cohort for first and second pillar, with and without a permanent shock to the equity premium. Initial rights based on the considered mix. The first number in the legend indicates the relative weight of the first pillar in the mix.

Birth cohort 1992	100-0	100-0 E shock	50-50	50-50 E shock	0-100	0-100 E shock
Median	41.3%	41.3%	65.3%	57.9%	84.7%	71.3%
P95	47.5%	47.5%	132.7%	111.3%	208.5%	168.8%
P5	35.4%	35.4%	39.5%	36.8%	39.7%	34.6%
P1	33.1%	33.1%	34.5%	32.6%	30.9%	27.3%

Table 5: Percentiles of replacement rates for birth cohort 1992 for different mixes of first and second pillar, with and without a permanent shock to the equity premium.

Birth cohort 1942	100-0	100-0 E shock	50-50	50-50 E shock	0-100	0-100 E shock
Median	61.4%	61.4%	62.4%	61.9%	69.3%	68.1%
P95	62.9%	62.9%	69.8%	69.1%	86.3%	84.5%
P5	59.9%	59.9%	56.8%	56.5%	56.9%	56.2%
P1	59.4%	59.4%	54.9%	54.6%	53.5%	52.8%

Table 6: Percentiles of replacement rates for birth cohort 1992 different mixes of first and second pillar, with and without a permanent shock to the equity premium.

Lastly, we look at certain transitions towards different mixes. We assume that the historic contribution rate to both pillars is 50%. From the first simulation year onwards, we permanently set the contribution rate to the first pillar at 0%, 25%, 50%, 75% or 100%.

An increase in first-pillar contributions immediately increases the benefits for current retirees, and reduces the benefits from the equity premium for currently working cohorts. As a consequence, Figure 6 indicates that cohorts born before 1975 prefer more first pillar in their pension scheme. The current participants still obtain the accrued second-pillar pension. For birth years between 1975 and 1990, the results depend on the risk perception. A strong attitude against risk (high γ) implies a higher weight for first pillar in the optimal mix. For higher levels of risk aversion γ, cohorts born after 1990 prefer a mix of first and second pillar schemes. The results for the youngest cohorts are most important, as they are not determined by initial funding conditions.

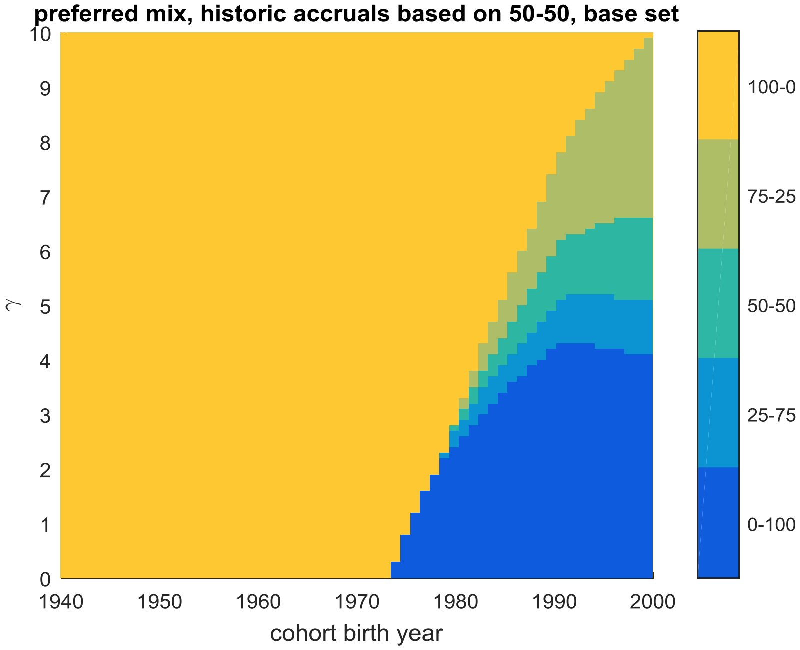

Figure 6: Preferred mix by cohort for different levels of risk aversion γ. Starting mix is 50-50. Initial rights based on the 50-50 mix.

The Appendix contains two sensitivity analyses with respect to the economic scenario set: one in which we introduce a zero lower bound on nominal interest rates, and one in which low interest rates are the new normal. The qualitative conclusion that mixes with a positive first-pillar weight only perform better in the tails of the probability distribution is robust to these alternative scenario sets. As in Figure 1 and Figure 5, young cohorts prefer a mix of first and second pillar pensions.

Discussion and conclusions

In our analyses, the higher expected return on second-pillar contributions leads to higher pensions in the median and in unfavorable quantiles with a more second-pillar oriented scheme. Nonetheless, young cohorts prefer a mix of first and second pillar schemes to benefit from diversification effects between both pillars. This result remains robust when we use a scenario set with permanently low interest rates; the reason for calls to expand the first pillar in the Netherlands.

Our results imply that even when low interest rates put pressure on funded pensions, a switch from a 50-50 mix to more pay-as-you-go funding is not an attractive long-term solution. The main intuition is the Aaron-Samuelson rule which indicates a lower return on contribution on the first pillar compared to the second pillar. In addition, the required time to switch back to a larger second pillar is substantially longer. There are alternative responses to the higher cost of retirement that do not further deteriorate the effective return on pension contributions: increasing the retirement age, increasing the contribution rate to second-pillar pensions, or accepting a lower replacement rate for a given level of contributions.

A mixture of these responses is being implemented in several Western European countries. Germany, Belgium, France, Greece and the Netherlands have or are in the process of increasing the retirement age. The guarantees on second-pillar returns have been lowered in Denmark, Sweden and Belgium. Germany is expanding its funded pillar (Riester-Rente) in light of population ageing. Some Eastern European countries reacted differently to the financial crisis. In 2011, Hungary reversed its shift towards more pre-funding and moved all private pension assets to the first pillar. Poland nationalized 51 percent of its second-pillar assets in 2014.[4]

An important caveat is that we do not look at within-cohort effects and the income distribution. With a non-earnings related first pillar, pay-as-you-go pensions play an important role against old-age poverty. Retirees may face pension adequacy problems if the first pillar becomes too small.

Appendix

Descriptive statistics

Demographics
The top plot in Figure 7 shows that life expectancy is expected to increase further in the future, possibly at a slightly lower rate. This prediction is in line with predictions from the United Nations (UN (2015) link), Statistics Netherlands (Statline, link), and the Dutch Actuarieel Genootschap (link). The bottom plot in in **Figure 7** indicates that the old-age dependency ratio sharply increases until 2040. This steep increase until 2040 is in line with the forecast of Statistics Netherlands (link) and due to a relatively large cohort born in the 1960s (link link). This substantial increase will lower the return on the first pillar over the next 25 years by more than one half. To justify a larger first pillar at the expense of a smaller second pillar, real wages need to double over some decades, or expected cumulative capital returns need to drop by one half, or a combination of the two.

[4] http://www.bloomberg.com/news/articles/2016-07-04/poland-to-overhaul-its-35-billion-private-pension-fund-industry

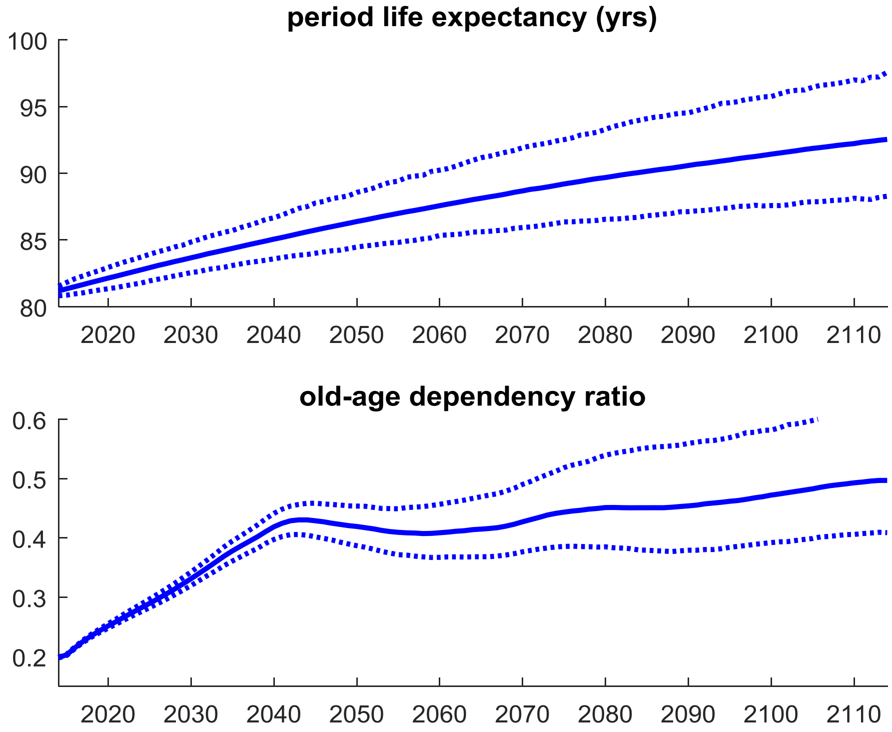

Figure 7: Period life expectancy and old-age dependency ratio.
Old-age dependency ratio is the ratio of the size of age at least 70 and size of age between 25 and 69. Solid lines are means over 2,000 simulations, medians are qualitatively the same. Dotted lines are 5% and 95% quantiles of the simulations.

Financial scenarios

The baseline financial scenario set is based on the model in Koijen, Nijman and Werker (2010). As a robustness check we consider two alternative financial scenario sets. This model is based on the model in Wu and Xia (2016). The ZLB scenario set implements a lower bound on forward rates at -0.25%. Muns (2016) contains more details on the estimation of this model with euroswap data. The low interest rate scenario set assumes that the current economic environment is likely to persist in the far future. This set has a lower bound of 0.25% on the 5-year interest rate. Van den Goorbergh et al. (2011) document the characteristics of the underlying model. In each scenario set, the portfolio return is the return of stocks and bonds less portfolio costs of 0.5% per year. Portfolio costs include asset management costs, transaction costs, and execution costs.[5]

[5] This estimate is based on 232 pension funds covering 99% of the pension market. http://www.lcpnl.com/nl/nieuws-en-publicaties/nieuws/2016/20161027_uitvoeringskosten_pensioenfondsen_2016/. It is a rough estimate as costs are sometimes subtracted from otherwise higher returns.

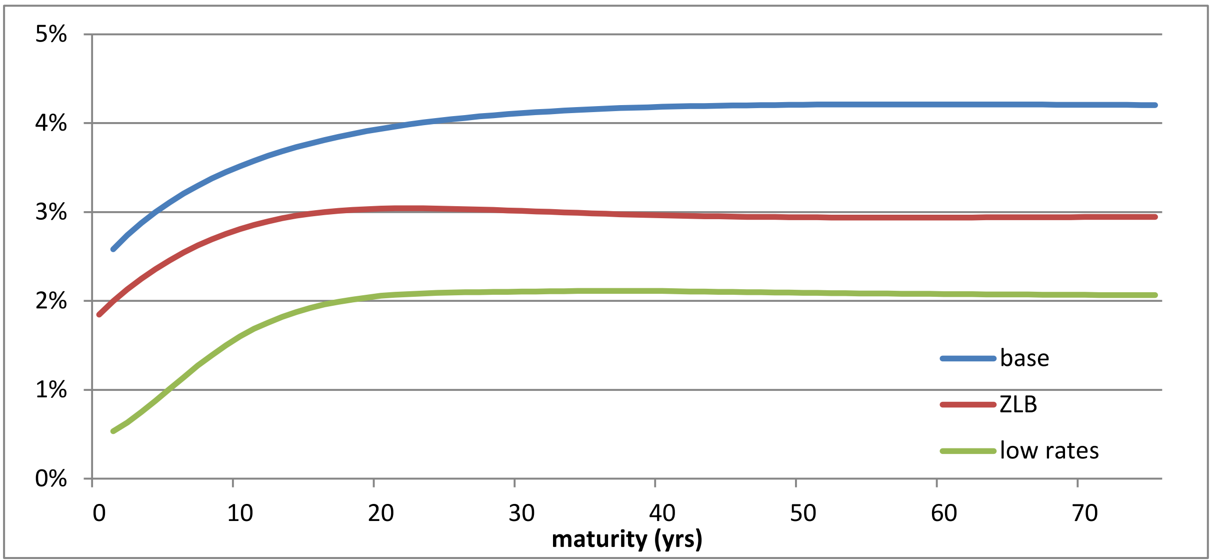

Figure 8: Expected term structure at the 100 year horizon in different scenario sets.

Figure 7 shows the different expected term structure at the 100 year horizon. Table 7–10 present descriptive statistics of the interest rate R at the 1 and 5 year horizon, the bond return *B*, the stock return *S*, the inflation rate π, and the wage inflation π[wage]. All statistics are derived from the 100 year horizon of 2,000 simulations. The top lines in each of the three tables represent the correlation matrix. The bottom lines are the mean μ, the standard deviation σ, the minimum and the maximum.

A striking difference between the sets is the lower interest rate in the ZLB scenario set and particularly in the low interest rate scenario set, despite the imposed lower bounds. Likewise, the bond portfolio with a constant duration of 5 years is one percentage-point lower in the ZLB scenario set, and 2.5 p.p. lower in the low interest rate scenario set. The probability on a negative 5-year interest rate is 13.8% in the baseline scenario set, while it is 1.2% in the ZLB scenario set and zero in the low interest rate set. In practice, the empirically observed 5-year euro swap rate is now for only a short period below zero.

Compared to the baseline scenario, the volatility of the investment returns (*B* and *S*) is somewhat higher in the ZLB scenario set while it is lower in the low interest rate scenario set. In the baseline scenario, real wage growth is positive since nominal wage growth tends to exceed price inflation. In the ZLB scenario set, it is assumed that wage growth is identical to the price inflation.

Baseline scenario set	R[1 yr]	R[5 yr]	B[5 yr]	S	π	π[wage]
R[1 yr]	1	0.98	0.26	0.21	0.89	0.76
R[5 yr]	0.98	1	0.32	0.21	0.87	0.75
B[5 yr]	0.26	0.32	1	0.08	0.35	0.37
S	0.21	0.21	0.08	1	0.19	0.15
π	0.89	0.87	0.35	0.19	1	0.84
π wage	0.76	0.75	0.37	0.15	0.84	1
μ (%)	2.74	3.21	3.85	7.17	2.03	3.31
σ (%)	3.15	2.92	5.82	17.94	1.65	2.16
min (%)	-7.81	-6.18	-15.48	-35.98	-3.09	-3.78

max (%)	13.29	12.60	27.21	74.50	7.39	11.42

Table 7: Descriptive statistics of the 1 year interest rate R[1 yr], the 5 year interest rate R[5 yr], the bond portfolio return B[5 yr] with a fixed maturity of 5 years, the stock return S, and the inflation rate π and the wage inflation rate π[wage]. Variables are annually compounded and at a horizon of 100 years over 2,000 simulations. The top lines represent the correlation matrix, the bottom lines are the mean μ, the standard deviation σ, the minimum and the maximum.

ZLB scenario set	R[1 yr]	R[5 yr]	B[5 yr]	S	π
R[1 yr]	1	0.91	0.03	-0.22	0.72
R[5 yr]	0.91	1	0.05	-0.21	0.66
B[5 yr]	0.03	0.05	1	0.00	0.02
S	-0.22	-0.21	0.00	1	-0.25
π	0.72	0.66	0.02	-0.25	1
μ (%)	2.00	2.46	2.91	7.84	1.74
σ (%)	1.47	1.36	7.25	21.83	0.72
min (%)	-0.25	-0.25	-17.30	-70.01	-0.73
max (%)	7.37	8.23	29.76	349.12	4.22

Table 8: Descriptive statistics of the 1 year interest rate R[1 yr], the 5 year interest rate R[5 yr], the bond portfolio return B[5 yr] with a fixed maturity of 5 years, the stock return S, and the inflation rate π. In this set, the wage inflation rate equals the price inflation rate plus 1.1%. Variables are annually compounded and at a horizon of 100 years over 2,000 simulations. The top lines represent the correlation matrix, the bottom lines are the mean μ, the standard deviation σ, the minimum and the maximum.

Low interest rate scenario set	R[1 yr]	R[5 yr]	B[5 yr]	S	π	π[wage]
R[1 yr]	1	0.82	-0.20	-0.10	0.61	0.44
R[5 yr]	0.82	1	-0.19	0.03	0.31	0.32
B[5 yr]	-0.20	-0.19	1	-0.11	-0.15	0.05
S	-0.10	0.03	-0.11	1	-0.01	0.11
π	0.61	0.31	-0.15	-0.01	1	0.47
π wage	0.44	0.32	0.05	0.11	0.47	1
μ (%)	0.54	1.01	1.44	5.75	1.37	2.40
σ (%)	0.88	0.53	2.14	14.92	1.18	1.26
min (%)	-0.04	0.25	-6.78	-50.85	-1.63	0.00
max (%)	10.85	7.19	12.99	60.82	6.37	10.37

Table 9: Descriptive statistics of the 1 year interest rate R[1 yr], the 5 year interest rate R[5 yr], the bond portfolio return B[5 yr] with a fixed maturity of 5 years, the stock return S, and the inflation rate π and the wage inflation rate π[wage]. Variables are annually compounded and at a horizon of 100 years over 2,000 simulations. The top lines represents the correlation matrix, the bottom lines below are the mean μ, the standard deviation σ, the minimum and the maximum.

Return bond portfolio

Baseline scenario set

By applying Ito's lemma on the dynamics of the state variables, a closed-form expression is available for the bond return B_τ in year t of a portfolio with constant maturity τ. Draper (2014) section 3.3 contains details on this expression and its derivation.

ZLB scenario set

In a zero lower bound-model, an analytical expression is only available for forward rates, not for the interest rates. As a result, no closed form expression is available for the return of a portfolio with a fixed maturity. We implement the following alternative.

The bond return B(τ, *t*) is the return of a bond portfolio with a constant duration of τ/2 years. This portfolio is approximated by zero-coupon bonds with a maturity of τ years issued over the last τ years. The value of the bond is the sum of the discounted payments

$$V_B(t) = \sum_{i=1}^{\tau} \frac{\left(1 + y_\tau(t-i)\right)^\tau}{(1 + y_\tau(t))^{\tau+1-i}} A(t-i) \qquad t = 0,1,2,\ldots$$

where $y_\tau(t)$ is the yield of a zero-coupon bond with maturity τ in period *t*, and *A*(*t*) is the amount invested in period *t*. In period *t*, the amount $(1 + y_\tau(t-\tau))^\tau A(t-\tau)$ of the maturing bonds is reinvested. The return on the bond portfolio is

$$B(\tau, t) = \frac{V_B(t) - V_B(t-1)}{V_B(t-1)} \qquad t = 1,2,3,\ldots.$$

The initial portfolio is chosen such that the payout stream is constant during the first τ years. Thus, the invested initial amount *A*(*t*) is proportional to $\left(1 + y_\tau(t)\right)^{-\tau}$ for $t = -\tau, \ldots, 0$.

Low interest rate scenario set

In this set the bond return of a portfolio with a duration of τ years is approximated by the price change of a zero-coupon bond with τ + ¼ years to maturity at the end of period t – 1. To determine this price, a stochastic spread sws_t determines the spread between the swap yield y_t and the bond yield:

$$B(\tau) = \frac{\left[y_{\tau+1/4}\,(t-1) - sws_{\tau+1/4}(t-1)\right]^\tau}{\left[y_{\tau-3/4}(t) - sws_{\tau+1/4}(t)\right]^{\tau-1}}$$

Sensitivity analysis

In the alternative scenario sets, there is a a stronger preference for the second pillar. This is best explained by the somewhat lower real wage growth compared to the baseline set. A low real wage makes the first pillar less suitable to protect against losses of purchasing power during the retirement period.

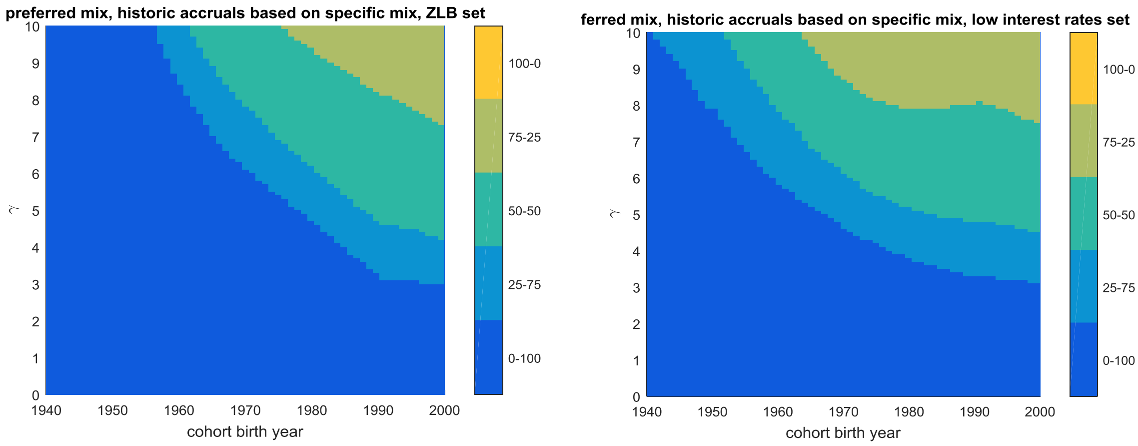

Figure 9: Preferred mix by cohort for different levels of risk aversion γ. Preferences are based on U(r, 0.98, γ) with ZLB scenario set (left) and APG scenario set (right). Initial rights are based on the considered mix.

Figure 10 and Table 10 and Table 11 contain the results for the sensitivity analysis on some of the percentiles of V(r) with the ZLB scenario set. The result that the long-term non-tail outcome is better the higher the weight of the second pillar remains robust. Nominal interest rates are slightly lower than in the baseline scenario set, but the effect on real second-pillar returns is compensated by a slightly higher stock return and lower inflation. In addition, the lower real wage growth makes the first pillar more unfavorable. The replacement rates of the second-pillar mixes (Table 10 and Table 11) are higher compared to the baseline results (Table 1 and Table 2).

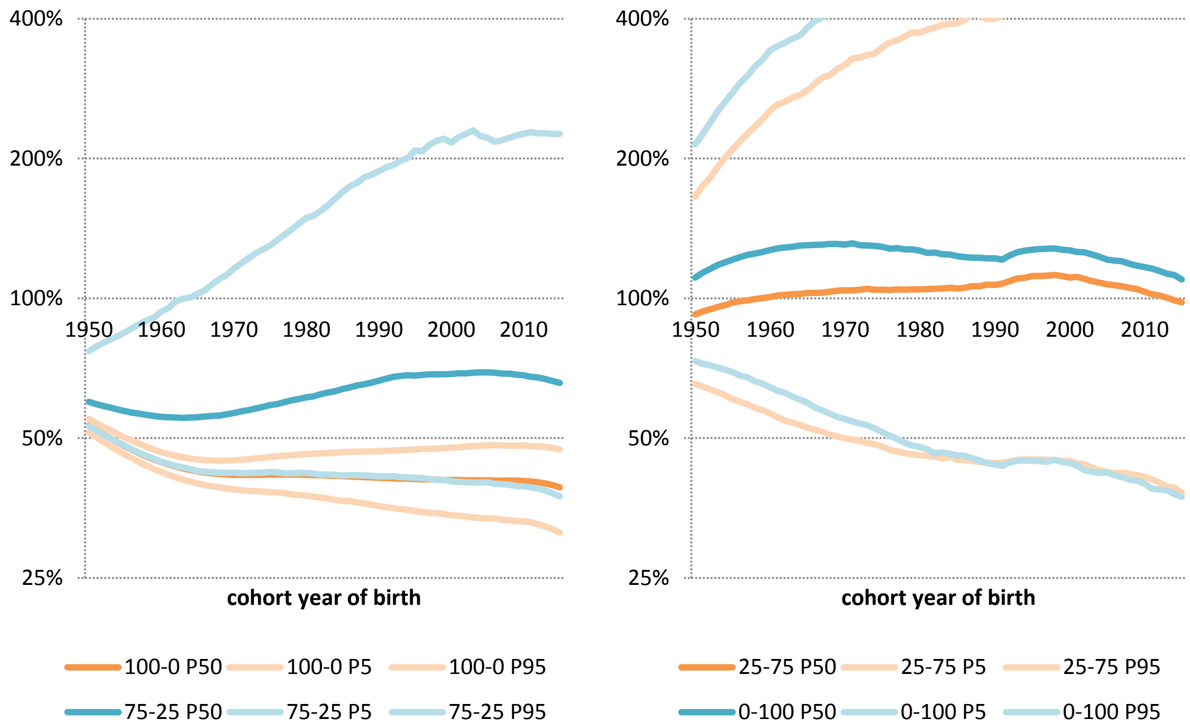

Figure 10: Replacement rates (median and 95% confidence interval of V(r)) per birth cohort for different combinations of the first and second pillar. ZLB economic scenario set. The first number in the legend indicates the relative weight of the first pillar in the mix.

Birth cohort 1992	100-0	75-25	50-50	25-75	0-100
Median	41.0%	67.7%	80.5%	108.9%	123.6%
P95	47.0%	193.5%	256.9%	419.1%	511.2%
P5	35.4%	41.4%	42.5%	44.6%	44.3%
P1	32.7%	36.2%	35.3%	34.6%	32.6%

Table 10: Percentiles of replacement rates for birth cohort 1992 different mixes of first and second pillar. ZLB economic scenario set.

Birth cohort 1942	100-0	75-25	50-50	25-75	0-100
Median	61.4%	65.1%	55.2%	85.3%	96.7%
P95	62.9%	73.6%	66.5%	122.4%	148.7%
P5	59.9%	61.1%	50.1%	70.0%	75.1%
P1	59.4%	59.8%	48.5%	65.2%	68.3%

Table 11: Percentiles of replacement rates for birth cohort 1942 different mixes of first and second pillar**. ZLB economic scenario set.**

Figure 11 and Table 12 and Table 13 show the outcomes for the low interest rate scenario set. All percentiles are a bit lower than in the main results because of the lower real financial returns in this scenario set. Still, the median and higher percentiles are strictly increasing in the weight of the second pillar. The first percentile again worsens in second-pillar-heavy variants. This effect is stronger for cohort 1992 than in the main results in Table 1.

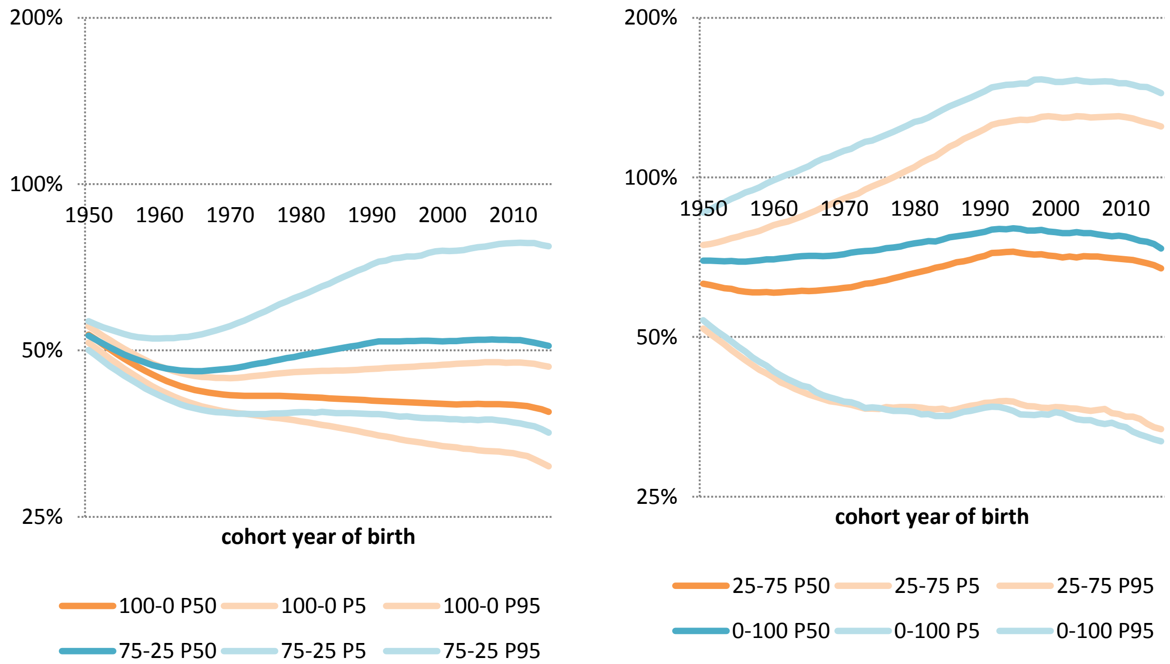

Figure 11: Replacement rates (median and 95% confidence interval) per birth cohort for different combinations of the first and second pillar. The first number in the legend indicates the relative weight of the first pillar in the mix. Alternative financial economic scenarios with permanently low interest rates.

Birth cohort 1992	100-0	75-25	50-50	25-75	0-100
Median	40.5%	51.9%	62.8%	72.1%	80.0%
P95	46.5%	72.7%	101.3%	126.7%	148.7%
P5	34.9%	38.2%	37.9%	37.8%	36.9%
P1	32.2%	34.4%	32.1%	29.3%	25.8%

Table 12: Percentiles of replacement rates for birth cohort 1992 different mixes of first and second pillar. Alternative financial economic scenarios with permanently low interest rates.

Birth cohort 1942	100-0	75-25	50-50	25-75	0-100
Median	61.4%	60.6%	63.1%	66.6%	70.6%
P95	62.9%	62.6%	67.3%	73.6%	80.3%
P5	59.9%	58.6%	59.0%	59.9%	61.1%
P1	59.4%	57.6%	57.4%	57.2%	57.2%

Table 13: Percentiles of replacement rates for birth cohort 1942 different mixes of first and second pillar. Alternative financial economic scenarios with permanently low interest rates.

The plots below provide qualitatively similar results as Figure 5. Thus, retired cohorts prefer a switch to a first-pillar-only mix, while young generations with a coefficient of risk aversion equal to 5 prefer a stable 50-50 mix.

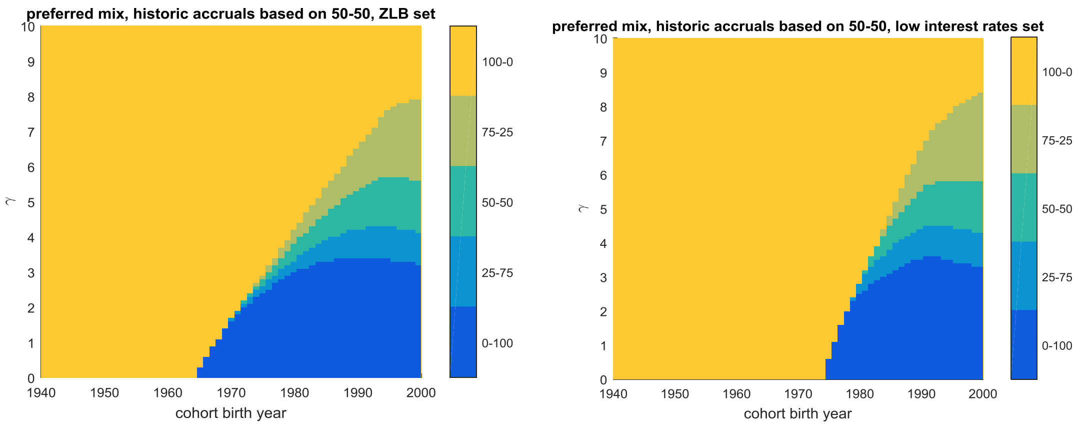

Figure 12: Preferred mix by cohort for different levels of risk aversion γ. Initial rights are based on a 50-50 mix with ZLB scenario set (left) and APG scenario set (right).

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