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Generational Pension Plan Designs

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Abstract

We propose a generational plan for the occupational pension provision in which people from the same generation are pooled in a generational fund. Each fund can set its own policies independently. This plan provides the benefits of differentiation missing in the prevailing collective plan and the benefits of centralized management and risk sharing which are missing in the individual plan. We compare the generational plan and the collective plan by imposing the same investment and contribution rates, find that the generational plan provides a higher welfare to the new entrants. This better performance is driven by the fact that the generational plan precludes any a-priori transfers while allowing for risk sharing via time diversification of long-term investment.

Keywords: Collective plan, generation, risk sharing, pension plan design
JEL classification: E21, E27, G23,

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1 Introduction

Pension plan participants and providers in many countries have experienced some rough times in the last decade. The hazard of underfunding and its impact on lower benefits and more volatility of sponsors' balance sheets has provoked the rethinking of the occupational pension contract design. A burgeoning literature on pension design has developed over the recent years. They are mostly design proposals from a central planner's perspective like Gollier (2008) and Beetsma, Bovenberg & Romp (2009) in order to produce the best risk sharing between generations. But given the current collective arrangement for the occupational pension plans in many countries, like the Netherlands, Switzerland and the UK, it is more feasible and effective to implement a gradual reform at the industry level than to redesign the entire pension system. Therefore this paper aims to propose such a design, called a generational pension plan, that can alleviate the problems with the current collective schemes while preserving some of the benefits of a collective arrangement.

The collective pension plan aggregates the pension assets contributed by both employers and employees in one money pool and invests this pool in the benefits of all plan participants. The collective plan can adjust its contribution, indexation and investment policies to absorb various shocks over multiple generations, thus achieving a welfare-improving intergenerational risk sharing (IRS) that is impossible for an individual plan design, shown in Cui, de Jong & Ponds (2009). The inherent problem of opaqueness regarding risk allocation, however, often make it a case of value transfers/redistribution, leading to a differential treatment to different generations a priori. This could considerably sabotage the sustainability of the plan and defeat the argument of welfare improving to all its generations.

A generational pension plan, as its name suggests, differentiates the pension provision to different generations, and precludes value transfers across generations from its nature. It contains multiple sub-funds, called generational funds, which each serve a particular generation. It differs from the traditional collective plan in that each generational fund has its own policies regarding investment, contribution and benefits payout. The contribution policy influences current consumptions, and the investment and payout policy adjust future consumptions. The combination of these policies can be customized to the preferences of a particular generation.

The setup of a generational plan, in its nature, is devoid of the risk allocation problems plaguing the collective plan. The investment is still organized at an aggregate level, allowing for exploiting investment expertise and the economies of scale in investment and operation costs. This distinguish it from the individual pension plan setup which often suffers from behavioral constraint (Benartzi & Thaler (2007)) and high operation costs (Bikker & de Dreu (2009)). A generational fund is organized around a particular generation, meaning that it is established when a new generation enters the labor market and ends when all its members die. This means that it lacks of the IRS. There are ways the IRS can be organized by introducing option traded among generations, but this is beyond the scope of this paper. This paper shows that even without the benefit of IRS, the generational plan provides more welfare to new participants than the current collective plan.

We compare the life-time welfare gained from entering respectively a collective and a generational plan. A collective plan is modeled according to its practical prototype that the current demographic characteristics and the prevailing contribution and indexation policies are taken into account. For the purpose of comparison, in a generational fund we impose the same contributions and investment policies as in the collective plan during the working phase. During the retirement phase, we assume a simple payout policy that the fund invests in risk free assets and the total accumulation is equally drawn down for each retirement year.

To make the comparison as close as possible to the real world, in modeling the financial markets, we do not assume i.i.d for the return dynamics of risky assets, but take the long-term characteristics of pension fund investment into account. For this purpose, we apply Vector AutoRegression to capture mean reversion of the risky assets. We allow for time-varying liabilities caused by the volatility of the discount rates to reflect the current accounting practice of market valuation of the liabilities. The yield curves are generated by the Nielsen-Siegel model that is reported to fit the data well.

The straightforward comparison shows that a new entrant is better off in participating a generational plan than a collective plan. A new participant in the collective plan receives fewer benefits than he would when having his own generational account. This result is driven by the embedded ex-ante value transfers required by the current liability structure in the collective plan. The status-quo of the collective plan asks the new participants to put in resource for the plan's retirees and makes the plan unattractive to new participants. In addition to the advantage in ruling out undesirable value transfers across generations a priori, the generational plan can smooth consumption shocks by allowing for time diversification through its investment strategy. Therefore we conclude that a generational plan is a very promising and sustainable design choice for future occupational pension arrangements.

This paper is structured as follows. First, we detail the problems with the current collective pension plan in Section 2. In Section 3 we introduce our new design in more detail. Section 4 presents the models for the pension designs that we use in our numerical analysis. Section 5 presents our data and the setup of the simulation analysis. In Section 6 the results are presented, and some concluding remarks and discussions are presented in Section 7.

2 Problems with the collective plan

The collective plan pools all assets of its participants in order to smooth shocks over multiple generations, and this pooling is welfare improving, shown in Cui et al. (2009). However, their results are obtained under two assumptions. First is that once the risk allocation rule across generation is determined, it has to be abided by across time/generaitons. Second is that all cohorts are of the same size, referred as the stationary age distribution in the paper. We argue that these two assumptions are very restrictive and the ignorance of the practical situation could be detrimental in achieving welfare improving in a collective plan. The first assumption on risk allocation rule can be hardly maintained in the practice. In cases of abnormal situations like highly overfunding or underfunding, the rule is often changed to satisfy the various requirements from stakeholders at the time due to a different financial, accounting and demographic environment. For example, in early 2000s many Dutch collective plans have changed from a pure DB scheme to a conditional DB scheme where full indexation is not guaranteed. After 2005 some plans have converted to collective DC scheme. Such changes of rules can lead to substantial value transfer across generations, as shown in Hoevenaars & Ponds (2008). Then the welfare improving becomes questionable. This opinion is also shared by Van Bommel (2006). The second assumption on the same cohort size allows that the mismatch risk equally shared among cohort groups is also equally shared among individual members in different cohorts. Thus from an individual's perspective his welfare is improved. But the real situation is that cohort sizes are often different rather than homogenous. From a participant's perspective, the optimal risk sharing rules for the members in one cohort is not necessarily the best for the members in another cohort. This also suggests that a differentiated risk sharing rules should be applied rather than the current uniform policies.

The drawback of the uniform policies in the current DB plan is also pointed out by Bovenberg, Koijen, Nijman & Teulings (2007) and Steenkamp (2004). For example, a collective plan has only one single asset allocation geared to the average participant of the plan. This can be problematic for the participants who deviate from the representative participant.

A collective plan is troubled by conflict of interests, especially when mismatch occurs. But a generational plan can avoid this by construction. Due to a lower degree of heterogeneity among its participants a generational plan incurs less negotiation costs and is in a better position to adjust to changes than a collective plan. For example, when an external shock occurs, both contribution and indexation rate can be used to manage the funding ratio. Contribution rate involves only the working participants, while the indexation rate matters more to the retirees than to the working participants as it is immediately realized in the benefits payment. So the degree of adjustment to contribution or indexation becomes a power play and this leads to a time-consuming and costly negotiation process between the working participants, the retirees and the sponsors.

Aging is an acknowledged fact, and it has a nonnegligent impact on a collective plan. It has a direct negative influence on the risk sharing capacity of the younger generation that the contribution rate will be a less effective tool for the funding ratio management. It also has an indirect influence on the investment policy. An increasing proportion of retirees in a pension plan will opt for a more conservative investment policy (Ponds & Van Riel (2007)). This in return means a lower investment return and consequently a higher contribution rate and a lower indexation for the working participants.

All these problems make the collective plan not a suitable and a sustainable plan design for the future participants.

3 A generational pension plan

The proposed generational pension plan, by construction, avoids the problems caused by the opaqueness in risk allocation in the collective plan, while at the mean time allows for more customization to individual preferences. We make a reasonable assumption that people of the same generation in a industry show similar risk preferences and share many similarities such as age and retirement schedule, which are important factors in saving and investment decisions over the life cycle. Under this assumption a generation can be characterized by a representative individual.

In the generational plan people of the same generation are pooled in one fund. As a result, there are multiple generational funds existing within a generational plan. For each generational fund, the preference of a particular generation can be satisfied by making generation-specific investment, contribution and indexation choices, which are almost impossible in a collective plan[1]. A generational fund ceases after all its participants die. When a new generation starts, a new generational fund is created.

A generational fund can adopt a DC scheme that it has a fixed contribution rate and a variable benefit payment. It can adopt a DB scheme that requires a variable contribution rate and pays a fixed benefit. In this case the fund will need to buy benefit guarantees from the market or possibly other funds. The fund can also have a hybrid scheme that both contribution rates and benefits can be varied. Whatever scheme is chosen, it reflects the particular preferences of a generation.

The implementation of a generational plan is not very different from that of the existing collective plan except that accounts for multiple generational funds need to be created and respective policies in contribution, investment and indexation need to be defined per gener-

[1]Though Ponds & Van Riel (2007) proposed age-dependent indexation policy, such differentiation is only limited to indexation and at most to investment to some degree.

ational fund. The execution of all fund activities and the knowledge are consolidated at the aggregate level to achieve economies of scale in operation cost and investments. Operational efforts regarding contribution collections and benefits payment are the same as in a collective plan except that the amount to be collected or paid out varies cross funds. Investment is still centralized and then delegated to asset managers, only that the overall strategic asset allocation is the aggregation of the individual generational fund's asset allocation. Investment results are allocated pro rata. As a result a generational plan can still exploit diversification opportunities. In addition the cost of investment will not increase a priori. These features makes a generational fund different from an individual plan and most importantly a generational plan allows for intra-generational risk sharing.

The design of a generational plan shares a similar spirit as the life-cycle funds thriving in the US (Viceira (2007)), where age prescribes investment policies for two reasons. Firstly, different ages imply different investment horizons and consequently different investment opportunities. Secondly, different ages imply different decompositions of total wealth into financial wealth and human capital. Especially, the correlation between human capital and returns on financial markets has an impact on the optimal investment policy. Compared with the life-cycle funds heavily promoted in the US now, the generational plan has two additional merits. First, it is industry-specific or company- specific, which allows for a better accommodation of the risk preferences of its participants than the life-cycle plans. Second, besides the investment policy, generational plans can also choose contribution and pay out policies to further improve participants' welfare while life-cycle funds only exploit the flexibility in the investment policy.

The idea of a generational plan originated from Teulings & de Vries (2006) who suggest creating generational accounts in a collective plan. In their paper they focus on the optimal investment choices for generational accounts. We develop their concept of a generational account, and transfer it into a fully fledged generational pension plan, in which not only portfolio choice but also contribution and indexation policies can be employed to accommodate a particular generation.

4 Modeling of a collective and a generational pension plan

This section describes how the two designs are modeled for comparison. We take the prevailing conditional DB plan in the Netherlands as a prototype for the collective plan. It has an incumbent participant composition with a given pool for contributions and a given pool for benefits payment. Its contribution and indexation policies are taken from the prevailing policy ladder applied in the practice that are conditional on the funding ratio of the plan. The generational plan is created from scratch where participants can choose any policies they prefer. For the sake of comparison, we impose the same contribution path and investment in the generational fund as in the collective plan during the working phase. After retirement, participants consume out of their savings in their generational account. In the modeling, we abstract from the role of sponsors, because in practice the sponsors have gradually reduced their responsibility in bearing the mismatch risk and simply assumed a role to pay a fixed contribution.

4.1 Modeling a collective conditional DB plan

In a collective conditional DB plan the contributions collected from all its participants are put in one monetary pool and invested as a unity in various assets. At the same time the plan pays the indexed benefits to the current retirees. To model the development of assets and liabilities, we need the initial values for assets (A_0) and liabilities (L_0), the premium base/pensionable salary ($Pbase$) and the benefits payout ($Bbase$). These initial values describe the starting status of the collective plan under study. In our later simulation, the starting values for these variables are taken from an existing pension fund in practice.

Each year the premium base increases with the salary growth rate (s), and the pension benefits payout increases with the cumulative indexation ($cumind_t^c$)[2]. All of the cash flows are assumed to take place at the end of each year. Therefore the total assets of the collective plan change positively with the investment return ($r_{A,t}$) and the premium collection (p_t^c:

[2] The effect of salary growth on the benefit payout is already discounted in the life-time average salary when computing the accrued rights.

contribution rate), and negatively with the benefit payout:

$$A_t^c = A_{t-1}^c(1 + r_{A,t}) + p_t^c * Pbase * (1 + s)^t - cumind_t^c * Bbase \tag{1}$$

This asset dynamics is similar to Cui et al. (2009) except that we are modeling in a discrete way.

Liabilities are marked to market, defined as the discounted value of the future expected benefits payout. This is different from Cui et al. (2009) where the liabilities are time-invariant. The change of the liabilities comes from three sources: actuarial factors, inflation and yield curve factors, discussed in Bauer, Hoevenaars & Steenkamp (2005). We assume the collective plan keeps its initial age composition during our simulation, thus we ignore the impact from actuarial factors.[3] Each year the expected cash flow of benefit payout increases with the granted indexation (ind_t^c) in that year. The influence from the yield curve is approximated by the return of a zero bond with a maturity matching the duration of the plan liabilities (m). We call this duration-matched bond return the liability return ($r_{L,m,t}$) to refer to the change in the value of liabilities caused by the discount rates. Thereby, the value of liabilities (L_t^c) each year increases with the liability return and the indexation as follows:

$$L_t^c = L_{t-1}^c(1 + r_{L,m,t}) * (1 + ind_t^c) \tag{2}$$

At the end of each year, the funding ratio (A_t^c/L_t^c) is computed to determine the contribution rate (p_{t+1}^c) and indexation rate (ind_{t+1}^c) for the coming year according to the rules in the policy ladder[4].

4.2 Modeling a generational plan

A generational plan have multiple generational funds, and each fund serves one particular generation with similar characteristics such as age, retirement date, and risk preference. We

[3] This is a conservative assumption. The reality is that due to aging the collective plan get a bigger benefits base and a smaller premium base. This will lead the collective plan unfavorable by new participants.

[4] A policy ladder is a set of rules specifying how indexation and contribution rates are dependent on the funding ratio. More details can be found in Section 5.2.2.

only model one generation, and they start working at time T_0, retire at time T_r, die at time T_d. A_0^g is 0 at time T_0.

The generational fund is a self-financed fund, meaning it resembles a DC scheme. For the ease of comparison, we impose that the generational fund applies the same contribution rates and investment policy as in the collective plan during the working phase. The change of the assets comes from two sources, premium collections (p_t^g) and investment returns ($r_{A,t}$).

$$A_t^g = A_{t-1}^g * (1 + r_{A,t}) + p_t^g * S_0 * (1 + s)^t \tag{3}$$

where S_0 is the initial salary level of the generation, and $p_t^g = p_t^c$.

As of retirement (T_r), the generation fund adopts a simple investment policy in risk free assets, and pays out benefits equally among the retirement years. The total expected assets TA to be distributed at T_r is

$$TA = A_{T_r}^g * (1 + rf)^{T_d - T_r - 1} \tag{4}$$

The benefits to be paid each year is $Be = TA/(T_d - T_r)$.

After the payment of the last benefits, the generational fund ends in 0 and is also closed.

5 Dada, simulation and method of comparison

Our modeling allows for a straightforward comparison between the two plan designs. We simulate the development of the two plans and evaluate them in terms of the utility gains from the perspective of a new entrant. This section describes the financial market and participant characteristics in our simulation.

5.1 Estimating the asset dynamics and the yield curve

It is assumed that pension funds will only invest in stocks and bonds, and their returns dynamics are captured by the one lag Vector Autoregressive (VAR(1)) as in Campbell &

Viceira (2005), in order to capture the long term features of returns. In this model, the stock and bond returns are described by their own lagged values and the lagged values of real interest rates, nominal interest rates, dividend yields and yield spreads as in Equation (5).

$$\mathbf{z}_{t+1} = \mathbf{A} + \mathbf{B}\ \mathbf{z}_t + \varepsilon_{t+1} \tag{5}$$

where $\mathbf{z}_t$ is a vector of stock returns, bond returns, the real interest rate, the nominal interest rate, the dividend yield and the yield spread. $\mathbf{A}$ is a 6×1 constant vector, $\mathbf{B}$ is a 6×6 coefficient matrix for $\mathbf{z}_t$, and $\varepsilon_{t+1} \sim N(\mathbf{0}, \Omega)$.

In order for the sample period to be non-selective, we use a sample period as long as possibly available to estimate return dynamics. We use the data provided by Robert Shiller[5]. The data covers the period between year 1872 and 2007, including yearly observations on the $S\&P$ stock index, the one-year interest rate computed from US 6-month commercial paper rate, the 10-year US T bond yield and the consumption price index.

The descriptive statistics, the coefficient estimates and the correlation matrix are shown in tables 1 and 2. As recognized in many studies, our estimates also show that lag dividend yield positively forecasts (0.07) stock returns but shocks to dividend yield and shocks to stocks are negatively related (-0.1). Accordingly, stock returns have a declining volatility over longer horizon.

The liabilities vary to the fluctuation in the discount rates generated by the yield curve. The yield curve data is collected from the monthly euro swap rate[6] sampled during the period between Jan 1999 and June 2007 for maturities running from 1 year up till 10 year, and 12-, 15-, 20-, 25-, 30-year. The data is obtained from DataStream. We use a dynamic Nielson-Siegel with AR(1) factor model proposed by Diebold & Li (2006) to model the yield curve. We use this model rather than the affine equilibrium model because this model fits yield curve

[5]Available on his homepage "http://www.econ.yale.edu/ shiller/data.htm". Campbell & Viceira (2002) use the same dataset.

[6]We use euro swap rate because it is the rate required by the Dutch Central Bank for the Dutch pension funds to use for the discount rate of their liabilities.

data well. In addition, it is popular in practice as many central banks use it.

$$y_t(\tau) = \beta_{1t} + \beta_{2t}(\frac{1 - exp^{-\lambda\tau}}{\lambda\tau}) + \beta_{3t}(\frac{1 - exp^{-\lambda\tau}}{\lambda\tau} - exp^{-\lambda\tau}) \quad (6)$$

where $y_t(\tau)$ refers to the interest rate for a maturity of τ-years. Factors β_{1t}, β_{2t} and β_{3t} respectively govern the level, slope and curvature of the yield curve. A graph of loadings on β_{3t} against maturity shows thats this loading reaches its maximum at mid-term maturity and it is regarded as a mid-term factor. In accordance with the common practice, we pick 30 months for τ, and choose a λ that maximizes the loading on β_{3t}. So the value for λ is 0.0747. In other words, at this value the maximum of the loading on β_{3t} occurs at 30 months. Every year, we regress yields of different maturities (namely, 1-10, 12, 15, 20, 25 and 30 years) on factor loadings of 1, $\frac{1-exp^{-\lambda\tau}}{\lambda\tau}$, and $\frac{1-exp^{-\lambda\tau}}{\lambda\tau} - exp^{-\lambda\tau}$, we get OLS estimates for β_{1t}, β_{2t} and β_{3t}. With the times series of the three βs, and using the following AR process we estimate the coefficients to describe the βs.

$$\beta_{i,t+1} = c_i + \gamma_i \beta_{i,t} + \epsilon_{i,t+1}, i = 1, 2, 3 \quad (7)$$

Using the estimates of coefficients and variance of the residuals of Equation (7), we can forecast future βs, then plug these forecasts in Equation (6) to generate the future yield curve.

5.2 Numerical simulation

The comparison between the two plans is done through a numerical simulation, as it is often done in Asset Liability Management (ALM) studies[7], see also Hoevenaars & Ponds (2008).

We make some assumptions on the characteristics of a new plan participant, the initial status of a collective plan, and the policy ladder that specifies the contribution and indexation policies.

[7]Numerical simulation is often used in ALM studies because the pension plan involves multiple objectives and quite a few independent time-varying variables, over which the optimization is notoriously complicated and even not possible. In addition the simulation result allows for a straightforward representation of pension dynamics.

5.2.1 Participant characteristics

The two plans are compared from a new entrant's perspective. This participant starts working at the age of 25, retires at 65, and earns an initial annual salary of €30,000. His salary grows at rate of s leading to a life time average salary $LTAS$ [8]. If he joins a collective plan, he pays contributions at a rate of p_t^c out of his salary to build his pension rights AR_t at the end of each year. He makes contributions for 40 years. For every year of service, he accrues additional new rights (NAR)[9]. Together with the previously accrued rights, the total accrued rights increase with yearly granted indexation. As of retirement at 65 he starts to receive benefits at the year end for 14 times and dies at the age of 80. Due to the conditional indexation the pension benefits continue to change each year after retirement. If he joins a generational plan, he pays contributions at a rate of p_t^g out of his salary in to his generational account for 40 years. As of retirement, he receives what has been accumulated in the account (Be).

5.2.2 Plan characteristics and the policy ladder

The initial status of a collective plan is taken from a real-life pension plan. The initial values of the assets (A_0^c), of the liabilities (L_0^c), the premium base ($Pbase$) and the benefit payment ($Bbase$) are assumed to be 200, 160, 32.5 and 6.1 billion respectively[10]. It essentially means the starting funding ratio is 125%. We also assume that the duration of a collective plan is constant at 15 years. Then the impact of yield curve changes on the liabilities is approximated by a 15-year bond return, which can be inferred from the simulated 15-year yield. The assets and liabilities develop as described in Section 4.1.

In the generational plan, the development of only one generational fund is simulated. The initial funding ratio is 0. The assets and liabilities develop as described in Section 4.2.

The policy ladder specifies how the contribution rate and indexation rate are adjusted according to the funding ratio. The contribution rate consists of two components: the base

[8]For example, for a 2% salary growth per year, $LTAS = \frac{(1+0.02)^{40}-1}{0.02} * 30000/40 = 45,301$.

[9]Following the above example, $NAR = \frac{1}{40} * LFAS * 70\% = 45,301/40 * 70\% = 793$, where 70% is the assumed replacement rate.

[10]Values are taken from a major Dutch pension fund ABP results in 2006 as an example. (See their 2006 annual report). However, note that absolute values are not important but the relative proportions matter as they reflect the maturity of the fund.

rate and an adjustment. The base rate is determined in an actuarially fair way such that the sum of contribution payment equals to the sum of nominal benefits given a certain replacement rate. Thereby the discount rate, the salary growth rate and the replacement rate determine the value of the actuarially fair base contribution rate. We take the historical mean real rate (2.77%) as the discount rate as the plan aims for full indexation. Replacement rate is set at 70%. Then a 0% salary growth prescribes a 11.22% base contribution rate. The adjustment ranges from -5% to 5%, meaning that the contribution rate is raised by 5% with a funding ratio equal or below 80%, and reduced by 5% with a funding ratio equal or above 150%. A linear rule applies in between.

The benefits are adjusted by $(1+ind_t)$, and $ind_t = \alpha * max(0, inflation_t)$. The indexation ratio α is defined as follows. When the funding ratio is equal to or below 80%, $\alpha = -0.2$, meaning a negative indexation. When the funding ratio is equal to 100%, $\alpha = 0$, meaning no indexation. When the funding ratio is equal to 135%, $\alpha = 1$, meaning a full indexation. When the funding ratio is equal to or above 150%, $\alpha = 2$, meaning even a catch-up of previous missed indexation. A linear rule applies when the funding ratio is in between the thresholds. The policy ladder, though looking a bit arbitrary, is chosen according to the practice. A graphic presentation of the contribution and indexation rate can be found in Figure 1.

In sum, our estimation and numerical simulation differ from other papers like Cui et al. (2009) and Gollier (2008) in three aspects. Firstly we capture the mean reversion in the stock returns to reflect the long term investment of a pension fund while others use i.i.d. for the asset returns. Hence in our simulation, a pension fund can exploit time diversification. Second, we allow for time-varying liabilities to reflect the current practice of market valuation of the liabilities, while others often use a constant value for liabilities ignoring the impact from changing discount rates and indexation ratios. Third, we use an existing pension plan from the practice as the starting status for our collective plan to account for the current demographic characteristics, while others assume the same cohort size. The last two differences make the simulated collective plan a reasonable representation of its practical situation.

5.3 Method of comparison

Because the collective plan applies contribution and indexation policies depending on the funding ratio, we apply a numerical simulation. The simulated consumption paths are used for a welfare analysis. We use a CRRA power utility function as in Cui et al. (2009), and the welfare of joining a plan is computed as

$$U = E_{T_0}[\sum_{T_0}^{T_d} e^{-\delta t} U_t(C)dt]$$

where $U_t(C) = \frac{C_t^{1-\lambda}-1}{1-\lambda}$, δ is the parameter for time preference, λ is the risk aversion coefficient, and

$$C_t = \begin{cases} S_0(1+s)^t(1-p_t), & \text{for } T_0 < t \leq T_r \\ AR_t(\text{in collective plan}), & \text{for } T_r < t \leq T_d \\ Be(\text{in generational plan}), & \end{cases}$$

For the ease of interpretation, we transform this welfare into the certainty equivalent consumption (CEC), derived from the following equation:

$$\sum_{0}^{T_d - T_0} e^{-\delta t} \frac{CEC^{1-\lambda} - 1}{1-\lambda} = U$$

6 Simulation results and analysis

With the estimates of Equation (5) for the asset returns and Equation (6) and (7) for the yield curve, we simulate 500 scenarios for stock and bond returns for a period of 54 years (the assumed lifetime of a generational fund). The average annual stock and bond return simulated for each year and the simulated average yield curve are shown in Figure 2. The overall average returns for stocks and bonds are 9.44% and 5.09% per year respectively.

6.1 Baseline scenario results

Figure 3 shows the dynamics of the funding ratio, contribution rate, indexation ratio and accrued benefits for the collective plan. Over time, the collective plan shows an improving funding status with a decreasing underfunding probability. Accordingly the average contribution rate declines and indexation ratio increases over time. The starred line represents the fully indexed pension benefits, and in comparison the pension benefits granted by the healthy collective plan is not as high as that. This shows that the funding surplus is not fully allocated to the participants under the prevailing policy ladder.

In the generational fund, we impose the new entrant pays what exactly he pays as if he were in a collective plan, but the contributions are saved in a generational account and are invested in the same way as in the collective plan. The dashed line shows the average simulated level of benefits. Table 4 shows the comparison of the welfare gains between the two plans. In the baseline scenario, the generational plan delivers €148 more for consumption for every year in life. This is a tremendous difference.

There are two factors to explain the better performance of a generational plan than a collective plan. First, the generational plan is not much worse than the collective plan in risk sharing. A key feature of the collective plan is that it can smooth shocks over and beyond the lifetime of a single generation via adjustment in contribution and indexation policies. A generational plan also provides such risk sharing but only limited to the working period of a generation. However, risk smoothing within a generation is not much worse than risk smoothing in a longer period. Take the whole history of the stock market in our sample period between 1872 and 2007 for an example, we find the annualized return of any 40-year horizon is within the range of [5.36%, 12.07%]. Compared with the mean stock return of 10.44% and the standard deviation of 17.63% for the whole sample period, this range is within half of the standard deviation around the mean. It says that historically there is no extremely negative or positive shocks that last more than a generation's time, or 40 years in this study. The standard deviation over any 40-year horizon is in an range of [15.18% 19.73%], while the standard deviation of the whole available history is 17.63%. Again this says the time diversification in a generation's time is not much worse than that in a longer period. Second, the generational plan is better in that there is no value transferred to other generations, which is the case in the current collective plan. With the same contributions, a participant gets more from a generational plan than from a collective plan. This shows that in the collective plan the inputs of the new entrants are also expected to be used for the current retirees and future entrants. An a-priori value transfers from the current new entrants to other generations are in place in the current collective plan and this makes the current collective plan inferior to a generational plan. The a-priori value transfers exist due to the funding status and liabilities of the current collective plan. To maintain its solvency, the collective plan with the currently mature participants has to take up the resources from the new entrants. Therefore ex ante the collective plan is not attractive to new participants. There will be also situations where the fund is in a big surplus at the time of entry. Then the collective plan is superior to the generational plan to the new entrants. But this must be at the expense of other generations. Therefore, in either situation, if the collective plan does not enforce the pre-set generation-neutral risk allocation rules consistently, there will appear a-priori value transfers for some generations. This will endanger the sustainability of the plan.

6.2 Other scenarios

In the generational plan all accumulations are consumed by members of that generation. But in the collective plan, affluent accumulation can be put in reserve and saved for future generations. Therefore a favorable external environment might inherently benefit the generational plan. We make a few other scenarios that describe less optimistic situations, and we find that the generational plan still performs better than the collective plan.

In Scenario 2, rather than using the real short rate to determine the contribution rate, we use the real investment return.[11] This means a 9.77% base contribution rate. A lower base contribution rate does not compensate the new entrants in the collective plan, and comparatively they still get a higher welfare from the generational plan (€27,813 rather than €27,655).

In Scenario 3, rather than using a normal distribution assumption of the asset returns,

[11] Real return of an investment of 56% stocks and 44% bonds is 10.44%*0.56+4.98%*0.44=3.25%. 10.44% and 4.98% are respectively historical mean stock and bond return.

we apply a student's t-distribution to reflect a more practical view of the financial market that the frequency of extreme values is higher than predicted by a normal distribution. With more financial market volatilities, the generational plan still performs better (€27,414 rather than €27,254).

In Scenario 4, we decrease the simulated equity premium by 2%. This reduces the welfare in both plans, but comparatively the generational plan grants €27,153 in annual consumption rather than €26,869 by the collective plan.

Scenario 5 is designed to show the impact of longevity risks. In this Scenario, participants'life is extended for one more year. Because this information is unexpected until the retirement year, the contribution policy are kept intact as in the baseline scenario. There is no change in the collective plan and participants receive one more year of benefits. In the generational plan, the life expectancy is disclosed at retirement, so the accumulation will be split among one additional retirement year, leading to lower annual benefits than the baseline scenario. Our results show that the generational plan still offers a higher CEC of €27,444 than €27,301 by the collective plan.

Summarizing all the scenarios, we find the current collective plan demands an a-prior value transfers away from the new entrants under various market conditions. On the contrast, the generational plan makes the risk sharing explicit and avoids the implicit value transfer among generations. Such advantages make the generational plan an economically and politically viable choice for future participants.

7 Conclusions and discussions

The conflicts of interests in a collective plan and the savings inadequacy in implementing an individual plan motivate us to consider a hybrid plan for the occupational pension provision. We propose a new design, called a generational plan, where people of the same generation are pooled in a generational fund. Each generational fund can set its own policies regarding investments, indexation and contributions.

We make an comparison between the generational fund and the current collective plan.

The collective plan is modeled from a Dutch practice that a policy ladder, time-varying liabilities and the current liability structure are accounted. The modeling of the generational fund resembles an individual DC account, but for one generation. For the sake of comparison, we impose that the generational fund applies the same investments and contribution rates. In addition, our modeling of asset return dynamics captures mean reversion for long term investment. The numerical simulations for various scenarios show that the generational plan delivers a higher welfare to a new entering generation than the current collective plan. The generational fund allocates all its accumulations to its generations, while the collective plan asks for resources sharing across multiple generations. The better performance of the generational plan is driven by the fact that the current collective plan imposes an a-priori value transfer away from the new participants. Facing this possibilities of an a-prior value transfer, the new participants should opt for a generational plan which prevents any a-priori transfers while allowing for risk sharing via time diversification of long-term investment. This paper does not explore the optimal setup of a generational plan, but the generational plan can surely improve welfare further by adopting life-cycle investments.

It can be argued that the indexation policy can be changed to make the collective plan welfare neutral to new participants, but this only solves the problem for the immediate new participants. For distant future participants with a different cohort size and facing a new funding status, the indexation policy may have to be changed again. Therefore the collective plan is vulnerable to the changing demographics and funding status.

There are some risks such as longevity risk that cannot be hedged in the existing market, or shocks that last beyond the lifetime of a single generation. For such situations, special arrangement can be set up between generational funds to trade undesired risks.

The proposed generational plan in this paper is meant for the reform in the occupational pension design. The optimal pension system consists many pillars and the best solution is not the same for every country. For countries with a sound pubic pension system and a thin individual pension market like the Netherlands, the purpose of the occupational pillar should be directed more to consumption smoothing and some customization, rather than the income redistribution as it is now happening in the collective plan. Therefore a generational plan is a meaningful consideration.

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Table 1: Descriptive statistics sample

Descriptive statistics for the entire sample of 136 yearly observations from 1872 to 2007. All numbers are in percentages. Variables are the real rate of US 6M commercial paper, *S&P* stock return including dividends, returns on the 10Y US T-bond, nominal rate of US 6M commercial paper, and yield spreads between 10Y T-bond and 6M commercial paper.

	Real short rate	Stock	Bond	Nominal short rate	Dividend yield	Yield spread
Mean	2.77	10.44	4.98	4.79	4.47	-0.11
Median	2.09	10.60	3.77	4.63	4.37	-0.03
Std. Dev.	6.64	17.62	5.90	2.76	1.65	1.53

Table 2: VAR estimates for asset returns

Panel A reports full sample OLS parameter estimates of VAR $z_{t+1} = A + Bz_t + \epsilon_{t+1}$,regressors are one-lag values of log real rate (r), log excess stock return (s), log excess bond return (b), log nominal rate (n), log dividend yield (d-p) and log yield spread (spr). T ratios are in parentheses. The last column is the R^2 for the respective equations. Panel B reports the standard deviations and correlation matrix for the residuals. Diagonal entries are the standard deviations; off-diagonal entries are the correlations.

Panel A

	$r(-1)$	$s(-1)$	$b(-1)$	$n(-1)$	$(d-p)(-1)$	$spr(-1)$	R^2
r	0.156	-0.061	0.128	0.321	0.004	-1.060	0.214
	(1.78)	(-1.90)	(1.23)	(1.33)	(0.31)	(-2.19)	
s	0.209	0.045	-0.204	-0.183	0.071	1.989	0.052
	(0.82)	(0.48)	(-0.68)	(-0.26)	(1.87)	(1.42)	
b	0.327	0.017	-0.293	0.346	0.007	2.875	0.339
	(4.59)	(0.64)	(-3.46)	(1.76)	(0.64)	(7.31)	
n	-0.088	0.008	0.018	0.891	-0.001	-0.116	0.739
	(-4.34)	(1.10)	(0.73)	(15.93)	(-0.47)	(-1.04)	
$(d-p)$	-0.652	-0.963	0.034	-0.682	0.924	-1.417	0.927
	(-3.82)	(-15.49)	(0.17)	(-1.45)	(36.15)	(-1.51)	
spr	0.043	-0.010	0.006	0.044	0.000	0.779	0.464
	(2.59)	(-1.70)	(0.31)	(0.97)	(0.10)	(8.60)	

Panel B

r	5.73	-0.21	-0.06	0.29	-0.05	-0.33
s		16.65	0.15	-0.26	-0.10	0.37
b			4.66	-0.70	-0.02	0.35
n				1.33	0.00	-0.79
(d-p)					11.16	-0.07
spr						1.08

Table 3: Specification of 6 scenarios and parameters

Scenario	Specifications
1	Simulated financial markets. Allocation of 56% stocks-44% bonds are held constant in both plans. Contribution policy and indexation policy in the collective plan are defined in Figure 1. The generational plan adopts the same investment policy and charges the same contribution rates as in the collective plan. After retirement, the generational plan invests in risk free assets and pays all its accumulations equally among the retirement years.
2	Contribution rate is set at 9.77% determined by using the real investment return of 3.25% as the discount rate. Others are the same as in Scenario 1.
3	Equity premium is 2% lower than the simulated. Others are the same as in Scenario 1.
4	The asset returns follow a student's t-distribution rather than a normal distribution. Others are the same as in Scenario 1.
5	Participants'life is extended for one more year, and this is unexpected until retirement. Others are the same as in Scenario 1.
Discount rate	4.79%, historical mean short rate, used when calculating money's worth.
Time preference (δ)	0.04
Risk aversion (λ)	5
Salary growth rate	0
Replacement rate	70%
Real short rate	2.77%, historical mean real rate, used when calculating actuarially fair base contribution rate.

Table 4: Comparison between the collective and generational plan

We calculated the certainty equivalent consumption (expressed in euros) that can be attained in participating the collective and generational plan for various scenarios. The specifics of the scenarios and the assumptions on simulation can be found in Table 3. Annual salary is €30,000 with no salary growth. The initial funding ratio is set at 125% in the collective plan.

	Collective	Generational
1. Baseline scenario	27,272	27,420
2. Lower base contribution rate	27,655	27,813
3. Lower equity premium	26,869	27,153
4. t-distribution of asset returns	27,254	27,414
5. Outliving one year	27,301	27,444

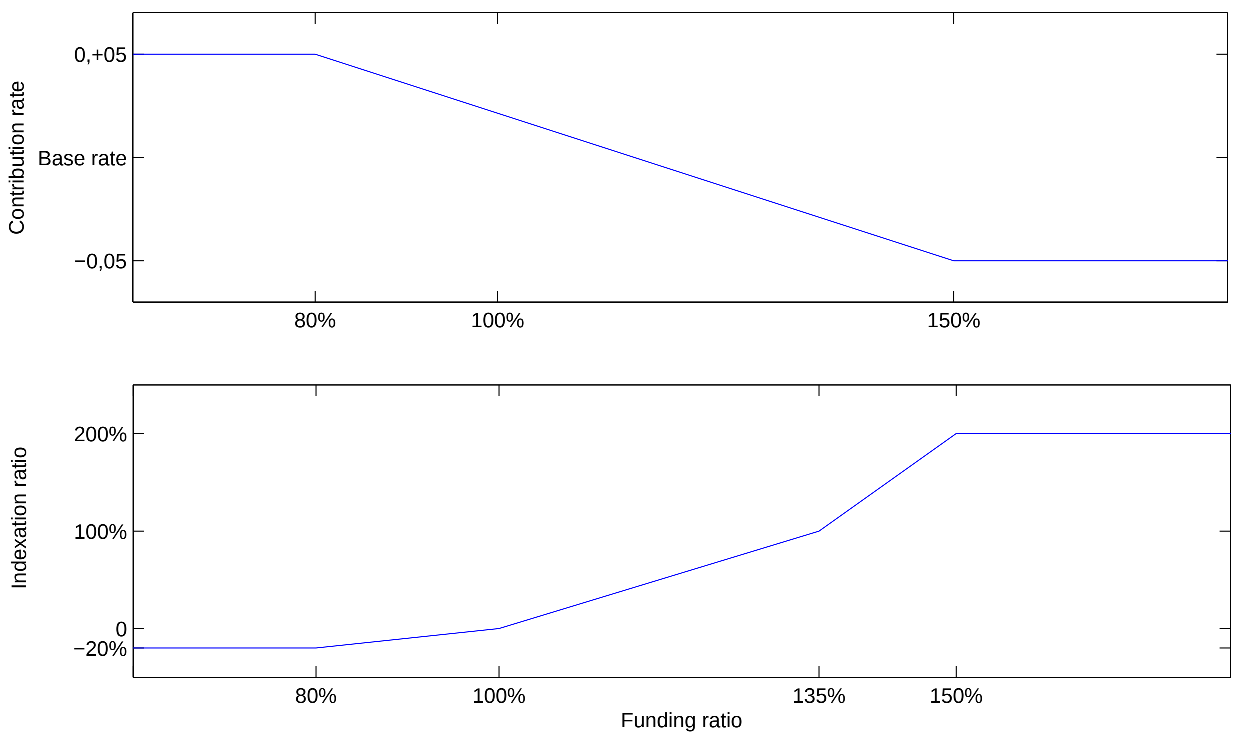

Figure 1: Contribution and indexation policy in the collective plan
The contribution rate is adjusted between [-5%, 5%] around the base rate depending on the funding ratio threshold of [80%, 150%]. The indexation ratio varies among [-20%, 200%] for different funding ratio.

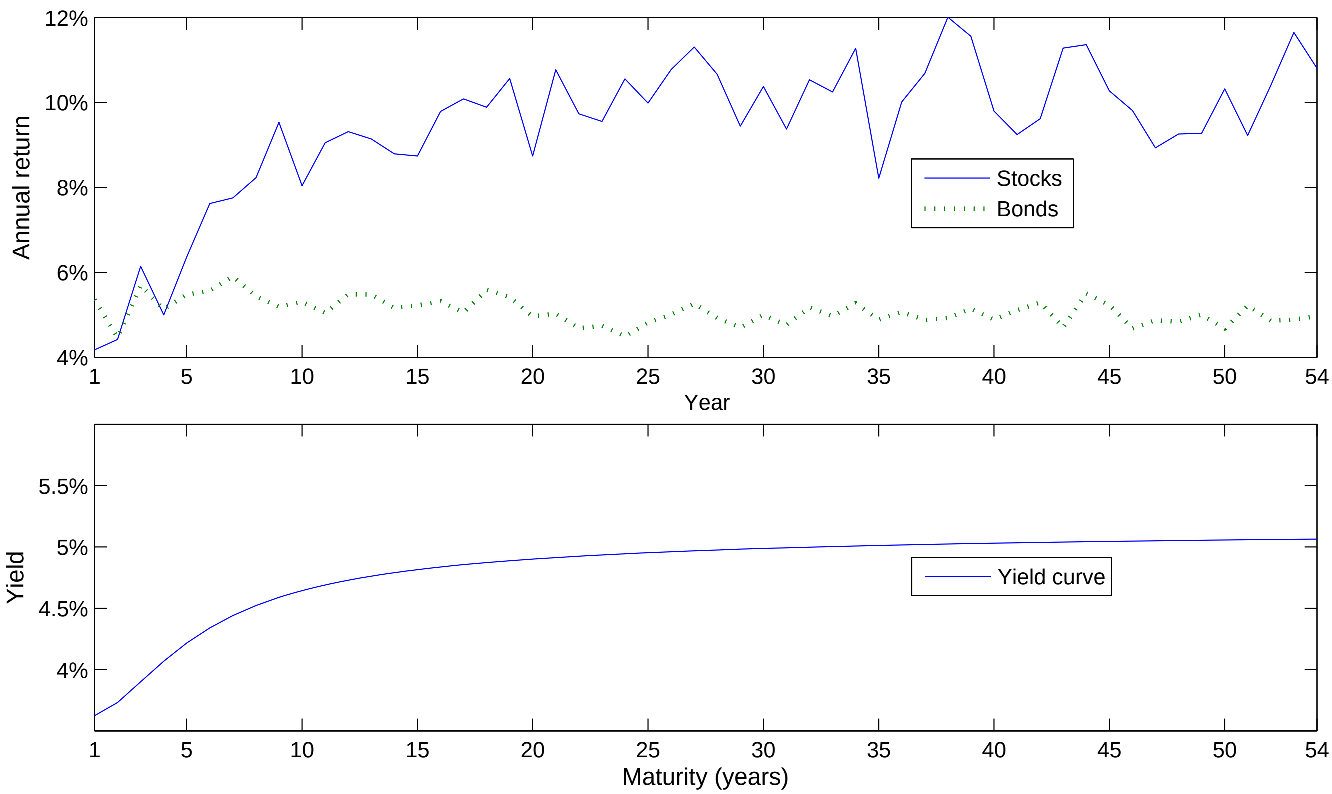

Figure 2: Simulated average annual stock and bond return for each year and yield curve
With Equation (5) for the asset returns dynamics, we simulate 500 scenarios for stock and 10-year bond returns over a period of 54 years. The upper graph shows the average annual stock and bond return for each year. Using Equation (6) and (7) we simulate 500 scenarios for the yield curve. The lower graph shows the average simulated yield curve.

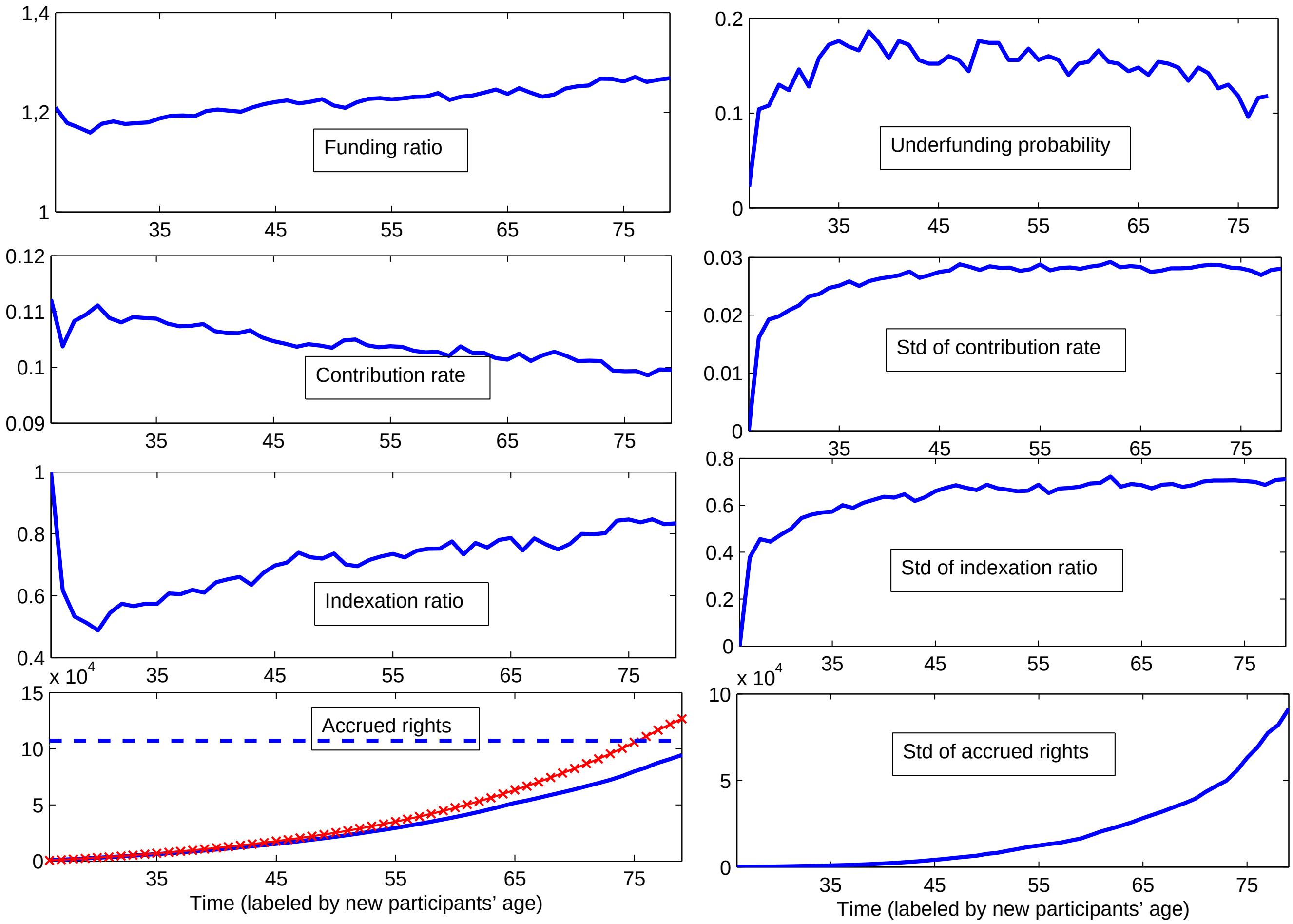

Figure 3: Fund dynamics in the collective plan over time

The first row draws the dynamics of funding ratio and underfunding probability of the pension plan over time which is labeled by the age of a new entrant. The second row shows the dynamics of means of the simulated contribution rate and its standard deviation. The third row shows the dynamics of means of the simulated indexation rate and its standard deviation. The last row shows the dynamics of means of the simulated accrued rights and its standard deviation. The star line shows the fully indexed accrued rights. The dashed line represents the average level of benefits granted by a generational plan.