Appropriate Structures and Mechanisms of Risk-Sharing in a Nursery Plan: Challenges for the Occupational Pension System of Japan[1]

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[1] Any views or thoughts expressed in this paper are strictly those of the author and have no relation to the organisation to which the author is belonging.

Abstract

Japan is now looking for appropriate risk-sharing designs to be introduced in the occupational pension system, paying attention to the desirability of benefits from the viewpoint of ensuring adequate income security and the sustainability of the plan that can endure economically unfavourable periods.

A Nursery plan, which sequentially combines a collective defined contribution (CDC) plan during the accumulation phase and a defined benefit (DB) plan during the withdrawal phase, may be one of the convincing candidates of new risk-sharing designs in Japan. However, a Nursery plan requires sensible considerations with regard to the accompanying inherent particularities. For instance, participants are vulnerable to the market shocks close to the annuity conversion and to the interest rate risk at the annuity conversion. Whereas some generations might have accumulated assets sufficient to ensure adequate income after retirement, other generations might not have been so lucky.

This paper analyses the risk structure of a stylised Nursery plan and proposes several measures to mitigate the risks and drawbacks of this DC-like hybrid plan. Especially, this paper introduces a levelling off function of the imbalances of the accumulation status among generations. This paper also proposes a mechanism of reallocating investment returns assuming a relationship of virtual borrowing and lending among generations. Furthermore, this paper devises the optimal age from which *personal* longevity risk is pooled, through quantitative evaluation of both *the pros and cons* of annuitisation.

From these considerations it is suggested that well-designed inter/intra-generational risk-sharing can make good the inherent shortcomings of DC-like hybrid plans to some extent and thus enhance the welfare of participants without exposing each generation to unaffordable risks. If we expect DC-like hybrid plans to play a reliable role in the overall old-age income security system, it is indispensable that these plans are equipped with appropriate inter/intra-generational risk-sharing structures and mechanisms.

1 Introduction

A Nursery plan is a sequential combination of a collective defined contribution (CDC) plan during the accumulation phase and a defined benefit (DB) plan during the payout (withdrawal) phase. This hybrid structure aims at transferring the investment risk during the accumulation period completely to individual participants while maintaining several favourable characteristics of DB plans during the payout phase, especially covering *personal* longevity risk and ensuring steady income after retirement as long as the beneficiary is alive.

However, this hybrid structure seems somewhat incoherent and requires sensible considerations on the accompanying inherent particularities. Firstly, the time horizon of investments during the accumulation phase depends on the ages of individual participants and therefore differs substantially. Secondly, when a market shock hits the plan occasionally, those generations close to the pensionable age (namely, the age of annuity conversion) have little chance to recover the investment losses they have suffered. Thirdly, participants face significant interest rate risk at annuity conversion. In addition, management of assets through the actual (i.e. not notional) accounts by participant might cause a problem that each participant recognises the balance of her account as her own wealth and does not want any risk-sharing nor losing control of the capital even after the annuity conversion. Besides, the sponsoring employer may not want to be exposed to the asset-liability mismatch risk during the payout phase any more.

Many of these particularities are common to individual defined contribution (pure DC) plans, because the accumulation phase of a Nursery plan is similar to that of a pure DC plan without investment choice. Thus a fundamental question would arise whether such a structure is appropriate as a trustworthy retirement benefit plan supplementing the social security and ensuring adequate and steady income after retirement at reasonable costs.

This paper analyses the risk structures of this hybrid plan and introduces several risk-sharing mechanisms to mitigate these risks (or drawbacks) mentioned above, while not largely altering the original purposes of this hybrid plan. In particular, this paper introduces a mechanism of reallocating investment risks and rewards among generations to mitigate the market shocks immediately before the annuity conversion. This risk-reward reallocation mechanism materialises a limited intergenerational risk-sharing in a collective pension plan without the help of derivative instruments in the market. This paper also proposes the optimal percentage of assets to be allocated for pooling *personal* longevity risk, in order to enhance the incentive to participate in the plan through taking care of the bequest motive of beneficiaries.

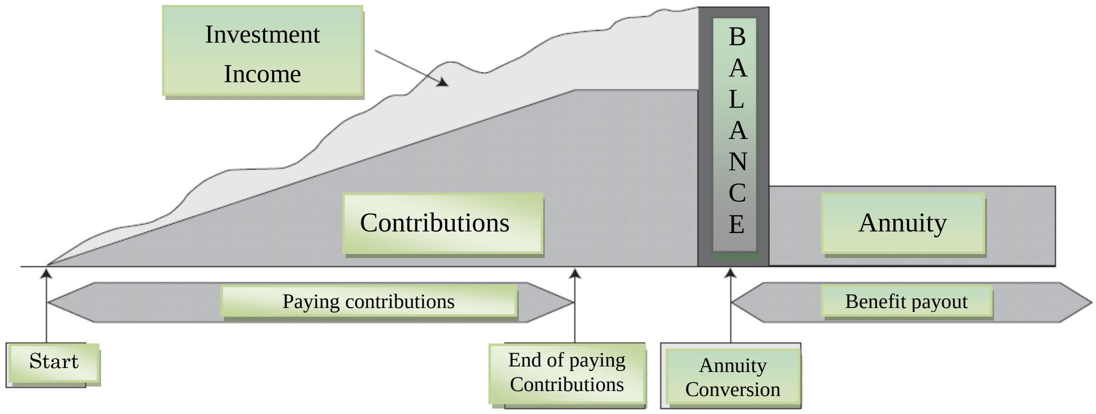
From these considerations it will be suggested that well-designed inter/intra-generational risk-sharing mechanisms can improve the inherent shortcomings of these DC-like hybrid plans and thus enhance the welfare of participants without exposing each generation to unaffordable risks. If we expect a CDC or DC-like hybrid plan to play a reliable role in the overall old-age income security system, it is indispensable that the plan is equipped with some appropriate inter/intra-generational risk-sharing structures and mechanisms.

This paper is composed as follows. Section 2 explains the basic structures of a stylised Nursery plan, highlighting the major differences from a typical cash balance (CB) plan and pointing out the major risks that plan participants will face. Section 3 introduces several risk-sharing measures to mitigate these risks and drawbacks to some extent, without imposing excessive burden on the pension fund or the sponsoring employer. Section 4 concludes.

2 Characteristics of stylised Nursery plan design

2.1 Sequential combination of collective DC and DB

In this section we introduce a stylised Nursery plan, where participation to the plan is voluntary and each participant pays contributions until she attains a predetermined age (for instance, age 65). The contributions paid are accumulated in her *actual* (not notional) account and managed individually.



However, her assets are combined with the assets of other participants and invested collectively. For simplicity, we assume that the portfolio of the total assets in the accumulation component is a composite of life-cycle funds determined for each generation. There are no investment options that participants can choose. Investment gains and losses are allocated at the end of each year to the account of each participant in the accumulation component.

The balance of each account is converted to a *nominal* life annuity at the prescribed age (for instance 65). The annuity conversion rate is determined each year based on the corresponding market long-term interest rates and expected future mortality rates constructed by each age cohort and sex. For simplicity and avoiding the adverse selection problem, we assume that there is no option of lump-sum benefits. At annuity conversion, a few percentages of the balance of her account may be charged as a risk margin.

There are no individual accounts in the payout phase, because the balance of each account in the accumulation component is converted to an annuity and is actually transferred to the payout component of the plan via the process of annuity conversion. The payout component has in essence a DB structure and therefore there are no individual accounts. In other words, the pension fund (or the sponsoring employer) bears all the risks after the annuity conversion, such as investment risk and *group* longevity risk that the mortality rates of beneficiaries improve beyond the original expectations.

For the time-being, we assume that the annuity is a life annuity with a guaranteed period. Namely, the annuity is composed of an annuity certain and a deferred simple life annuity. The pension benefits from the deferred simple life annuity will be paid from the end of the payout period of the annuity certain on condition that she is still alive. When the annuitant dies during the payout period of the annuity certain, the remaining capital of the annuity certain will be paid to her family. However, she will entirely 'lose' the capital allocated for the deferred simple annuity. On the other hand if she dies before the age of annuity conversion, the balance of her account is of course fully paid back to her family.

2.2 Differences from a Cash Balance plan

The benefit design of this stylised Nursery plan resembles to that of a typical CB plan. However, we should pay attention to the following three major differences. Firstly, negative indexation during the accumulation phase is normally not allowed in a CB plan, whereas it should be admitted in a Nursery plan. In a CB plan, the nominal (or real) rate of the 'interest credits' (namely, the rate of revaluation of accumulated assets) is predetermined or the formula of determining the interest credit rates is prescribed exactly in the benefit rule of the plan as a function of some economic indices. In Japan, it is not permitted to link the interest credit rates to the actual rates of return on investments. In essence, in a CB plan, participants are not directly exposed to actual investment risk.

Secondly, in a CB plan the discount rates used for calculating the annuity conversion rates may deviate from the market interest rates. However, in a Nursery plan the discount rates for annuity conversion should not largely deviate from the corresponding market interest rates if the interest rate risk at annuity conversion has to be borne solely by the participant concerned. The former should be recognised as an important function of risk-sharing among the participants and/or between the employer and the participants of a CB plan. It should be reminded that in a CB plan the balance of a notional account does not have specified one-to-one correspondence to the actual amount of assets. Therefore, even if the discount rates for annuity conversion deviate from the market interest rates at the date of annuity conversion, it does not necessarily mean that the market interest rate risk is fully borne by the plan and/or the employer.

Thirdly and most importantly, in a CB plan there is no financial firewall between the accumulation component and the payout component. The funded status of a CB plan is a measure on the financial situation of the plan as a whole and there is no peculiar funded status of the accumulation component or of the payout component. However, in a Nursery plan the payout component is financially separated from the accumulation component. The accumulation component of a Nursery plan is always fully funded and insulated from the financial status of the payout component. It can be said that a CB plan aims at partially transferring the investment risk during the accumulation phase to the plan participants, whereas a Nursery plan aims at completely transferring the investment risk in the accumulation component to the plan participants and segregating the payout component from the accumulation component by establishing a unique financial firewall. In a Nursery plan, there is thus no possibility of risk-sharing between active participants and retired beneficiaries.

2.3 Major risks and drawbacks of a Nursery plan

From the above observation, it is clear that the critical points of a Nursery plan lie on the structure of annuitising the accumulated assets at a specified age. Major risks of the participants of a Nursery plan thus concentrate in the periods close to the annuity conversion and in the process of annuity conversion.

2.3.1 Risks during the accumulation phase

The accumulation phase of a Nursery plan is same as an individual DC plan that provides each participant with only a default fund. Then, in a Nursery plan, participants in the accumulation phase are directly exposed to investment risk without being given any freedom of choice with regard to investments. Theoretically, those who bear investment risk should be given the opportunity of determining the portfolio structure. However, it is often observed in pure DC plans that many participants are staying on the default option and do not make any active decision. In addition, administration costs can be reduced significantly if there are no alternative investment options available. Therefore, the setting of this stylised Nursery plan may be justifiable when the investment risk is within the affordable range for the majority of plan participants.

One of the major risks during the accumulation phase is that the balance of the account of each participant at the end of the accumulation phase is not sufficient for her targeted monthly benefits. Some generations might have been able to accumulate sufficient assets thanks to favourable economic conditions during their accumulation phase. But other generations might not have been so lucky. This risk is especially important from the viewpoint of ensuring adequate steady income after retirement.

More specifically, participants are extremely vulnerable to the market shocks close to the end of their accumulation phase. Generations close to annuity conversion have accumulated largest amounts of assets and will be affected by the market shocks most significantly among the generations in the accumulation phase. However, it is said that this risk can be mitigated by implementing the so-called lifecycle investment strategy, which gradually increases the weight of the hedging portfolio that does not contain stocks.

In any way individual generations cannot get rid of the so-called annuity risk that the balance of their accounts at the end of the accumulation phase is not sufficient due to the overall economic environments during their accumulation periods. This risk is difficult to be mitigated without introducing some intergenerational risk-sharing mechanisms. In a pure DC plan, there is no possibility of smoothing out the unevenness of the 'funded' status (in comparison to the targeted benefits) among generations. But the accumulation component of a Nursery plan has a collective DC structure and there remains the possibility of incorporating some intergenerational risk-sharing mechanisms. This is one of the important favourable points that are common to the collective DC plans in the Dutch context and we will consider this issue in section 3.

2.3.2 Risks and drawbacks at annuity conversion

One of the basic requirements for a Nursery plan from the standpoint of the sponsoring employer is minimising the asset-liability mismatch risk at annuity conversion and during the payout phase. This can be achieved by using the corresponding (long-term) market interest rates as the basis of the annuity conversion and implementing so-called cashflow matching strategies during the payout phase. Especially, the discount rate for annuity conversion should not positively deviate from the market interest rate. Plan participants are thus vulnerable to the interest rate risk at the date of annuity conversion.

According to the conventional actuarial practices, the discount rates have to be adequately conservative and not necessarily tied to the fluctuations of market interest rates. However, to keep the discussion simple, we assume in this section that any intergenerational risk-sharing function is excluded from the plan. Then we cannot use 'smoothed' interest rates as the basis of the discount rates because it implies that an intergenerational risk-sharing function is implicitly incorporated.

Besides, the size of the risk margin required for coping with the risks after annuity conversion does not have direct relationships to the absolute level of the market interest rates at annuity conversion. Furthermore, we need not pay attention to the risk of adverse selection since this stylised Nursery plan does not provide the option of selecting lump-sum benefits. Although the plan may keep the discounts rates lower than the market interest rates, the spreads between the two rates should correspond precisely to the required risk margin which is supposed to be largely constant on a medium-term basis. The discount rates should thus be tied directly to the estimated short-term fluctuations of market interest rates when we exclude intergenerational risk-sharing functions in the plan.

The above consideration does not mean that the risks at annuity conversion cannot be mitigated without introducing intergenerational risk-sharing functions. It may be possible to overcome the *nominal* or *real* interest rate risk at annuity conversion by appropriately incorporating a hedging portfolio in the lifecycle funds of individual generations during the accumulation phase. In section 3, we will consider a mechanism of reallocating investment returns among generations, assuming a relationship of virtual borrowing and lending of bonds among generations in the accumulation phase.

2.3.3 Risks and drawbacks during the payout phase

The payout component of a Nursery plan is, in essence, a DB plan since it guarantees annuity benefits to the beneficiaries on the *nominal* (or *real*) basis. Then the risks during the payout phase have to be borne by the sponsoring employer or the pension fund. However, as noted in section 2.3.2, in this section we exclude the possibility that the sponsoring entity shares the risks during the payout phase with the beneficiaries. Then the pension fund has to bear the risks and therefore the fund has to charge an appropriate amount of risk margin. In addition, the pension fund has to implement asset-liability matching strategies to minimise the interest rate risk and the investment risk during the payout phase. As a result, the expected investment return during the payout phase will inevitably become lower than those of ordinary DB plans. In other words, the amounts of annual pensions provided by a Nursery plan are supposed to become smaller than those provided by ordinary DB plans. This should be recognised as one of the major drawbacks of a Nursery plan.

The risks during the payout phase are originated from three sources. Firstly, as mentioned in section 2.3.2, the amounts of liabilities fluctuate along with the market interest rate fluctuations. Secondly, the investment performance may not precisely follow the fluctuations of liabilities. Thirdly, the actual mortality rates may improve beyond the original expectations which are taken into account for determining the annuity conversion rates. The risk margin charged in the process of annuity conversion should be based on proper evaluation of these three risks.

From the standpoint of a participant, it may not be not a negligible risk that she dies before attaining the predetermined age at which the guaranteed period of the life annuity ends and she entirely ‘loses’ the capital invested in the deferred simple life annuity starting at that age (see 2.1). This is effectively equal to abandoning control of a part of her wealth in the Nursery plan due to the compulsory annuity conversion. For those who have bequest motives, this might be recognised as one of the major risks accompanied by annuity conversion. Unpopularity of annuitisation among the general population, which has been observed in many countries including Japan and is often dubbed ‘annuity puzzle’, is supposed to be originated from the risk of losing control of the capital allocated for covering *personal* longevity risk. In section 3.3.1 we will consider the optimal age from which *personal* longevity risk should be pooled, taking into account the risk of losing control of capital by annuitisation.

3 Measures for mitigating the risks of a stylised Nursery plan

3.1 Risks or drawbacks in the accumulation component

3.1.1 Imbalance of the funded status among generations

In this section we will consider several possible measures for mitigating the risks and drawbacks explained in the previous section. As explained in section 2.3.1, some generations might have been able to accumulate targeted amounts of assets for ensuring adequate pensions, thanks to the economic environments during their accumulation phase. But other generations might not have been so lucky. Whereas a DC plan has no funding shortfall and is always 100% funded, it does not mean that the balance of the account of each participant is sufficient to provide her with the targeted amounts of benefits.

Even for a pure DC plan and also for the accumulation component of a Nursery plan, we can define a hypothetical funded status of each account which is the ratio of the balance of her account to her targeted amount at the measurement date. Here we have to remind that this stylised Nursery plan provides each participant with only a default fund depending on her age. The difference of the funded status among generations at annuity conversion is thus not the responsibility of each participant. The economic environments as a whole during the accumulation phase are beyond the efforts of individual participants.

Then such a question would arise whether the imbalances of the funded status among generations in this Nursery plan should be levelled off. It is possible to introduce such a levelling off function into the accumulation component of this Nursery plan since the accumulation component has a collective DC structure. In addition, it should be reminded that traditional DB plans are naturally equipped with an implicit levelling off function since there is no difference in the levels of pensions provided to individual beneficiaries. Thus, introducing a levelling off function in this stylised Nursery plan with regard to the unevenness of the funded status among generations is not an eccentric idea and is worth paying serious considerations.

One possible levelling-off mechanism is as follows. When the cumulative *real* rate of return on investments at annuity conversion is greater than the predetermined *maximum* rate, then the participant shall leave the ‘surplus’ in a special buffer fund of the plan. Conversely, when the cumulative *real* rate of return is less than the predetermined *minimum* rate, then the ‘shortfall’ shall be made up for before the annuity conversion by the ‘subsidy’ from the special buffer fund.

The former is equivalent to holding the short position of a European call option where the underlying asset is the balance of the account, the strike price is the value of the assets that will be achieved by the prescribed *maximum* rate and the date of maturity is the time of annuity conversion. Similarly, the latter in the previous paragraph is equivalent to holding the long position of an European put option where the underlying asset and the date of maturity are both same as in the former call option but the strike price is the value of the assets which will be achieved by the *minimum* rate.

It is possible to determine the *maximum* rate as a function of the *minimum* rate so as to ensure economically fair trade between each participant and the special buffer fund. We can thus consider a mechanism of mitigating the risk that some generations may have not accumulated sufficient assets during the accumulation phase, without imposing additional burden on the plan or the sponsoring employer (namely, the owner of the special buffer fund). Of course, initial construction of the special buffer fund has to be borne by the employer, who is the owner of the fund.

It should be noted that from the standpoint of individual participants the expected rate of return on investments would inevitably decrease when the above levelling off function were introduced. This can be confirmed by evaluating the market consistent value (P) of the put option with the given *minimum* rate using the martingale measure and obtaining the *maximum* rate with which the market consistent value of the call option (C) becomes equal to the put option (P) and then calculating the expected rate of return on investments under the condition of the *minimum* and *maximum* rates and using the original probability measure. But it is also easily anticipated if we consider what will happen when the *minimum* rate gradually increases. The *maximum* rate will then gradually decrease and eventually the two rated will coincide at the point of the risk free rate, if any possibility of arbitrage is excluded.

Put it in other way, the narrower is the spread between the *minimum* and *maximum* rates, the smaller the expected return becomes. We have to accept certain level of uncertainty on the investment return if we want to anticipate investment returns greater than the risk free rate, while sticking to ensure economically fair trades between individual participants and the special buffer fund.

3.1.2 Market shocks close to the annuity conversion

In a Nursery plan, the participants are extremely vulnerable to the market shocks occurred close to the end of their accumulation phase. Of course, as noted in section 2.3.1, this risk can be mitigated by implementing a lifecycle investment strategy where the weight of 'risky' assets (or the speculative portfolio) decreases gradually as the participant becomes older. The weight of the hedging portfolio shall reach to 100% when the relative risk aversion of the participant becomes infinite. It is generally supposed that the relative risk aversion of the average participant becomes greater as she gets older and finally approaches to infinite when she is immediately before the annuity conversion.

As the first step we consider the case where the participant aged n ($n \leq 64$) at the beginning of the year t is only concerned about the *nominal* amounts of the annual pensions after the annuity conversion. Then the hedging portfolio becomes the one aiming at hedging the risk that the *nominal* amounts of the annual pensions decrease due to market fluctuations during the year t. Let r_{t+k+1} denote the log nominal forward rate for the year $t+k$, and put $r_{t+1} = 0$ for convenience. Then the optimising problem of the portfolio vector $\boldsymbol{\alpha}_t$ under the constant relative risk aversion (CRRA) preference on the funding ratio F_{t+1} at the end of the year t:

$$\max_{\boldsymbol{\alpha}_t} \mathrm{E}_t\left[\frac{F_{t+1}^{1-\gamma}}{1-\gamma}\right], \quad F_{t+1} = \frac{A_{t+1}}{L_{t+1}} = \frac{A_{t+1}}{\exp\{-\sum_{k=1}^{65-n} r_{t+k}\}(\bar{a}_{\overline{15}|} + {}_{15|}\bar{a}_{65})}$$

reduces to the following mean-variance problem, on the assumption that the asset return follows log normal distribution (See for instance Hoevenaars [2008]).

$$\max_{\boldsymbol{\alpha}_t} \mathrm{E}_t\left[r_{F,t+1}\right] + \frac{1}{2}(1-\gamma)\,\mathrm{Var}_t\left[r_{F,t+1}\right]$$

Here, $r_{F,t+1}$ denotes the 'return' of the funding ratio during the year t. It should be noted that the liability value L_{t+1} varies along with the expected *real* log forward rates r_{t+k} ($k = 2, 3, \Lambda$) and *nominal* interest rates at the date of the annuity conversion.

Then usual mean-variance analysis shows that the efficient portfolio is expressed as a linear combination of the speculative portfolio and the hedging portfolio with the weights $\frac{1}{\gamma}$ and $1-\frac{1}{\gamma}$ (See for instance Hoevenaars [2008]).

$$\boldsymbol{\alpha}_t = \frac{1}{\gamma} \times \tilde{\boldsymbol{\alpha}}_{S,t} + \left(1-\frac{1}{\gamma}\right) \times \tilde{\boldsymbol{\alpha}}_{H,n}, \quad \gamma > 1$$

$$\tilde{\boldsymbol{\alpha}}_{S,t} = (\boldsymbol{\Sigma}_{AA})^{-1}\left\{ \boldsymbol{\mu}_{A,\,t+1} + \frac{1}{2}\boldsymbol{\sigma}_A^2 \right\} \quad : \text{Speculative portfolio}$$

$$\tilde{\boldsymbol{\alpha}}_{H,n} = (\boldsymbol{\Sigma}_{AA})^{-1}\,\boldsymbol{\sigma}_{AL} \quad : \text{Liability-hedging portfolio}$$

Here $\boldsymbol{\mu}_{A,\,t+1}$ denotes the vector of expected annual log returns of the assets during the year *t*, $\boldsymbol{\Sigma}_{AA}$ denotes the covariance matrix of the log returns of the assets, $\boldsymbol{\sigma}_A^2$ denotes the variance vector of log returns of assets and $\boldsymbol{\sigma}_{AL}$ denotes the covariance vector of individual asset classes and the liability value L_{t+1} . It should be noted that since the liability value of the participant aged *n* depends on the *real* log forward rates r_{t+k} $(k = 2, 3, \Lambda\ , 65-n)$ the hedging portfolios is age-dependent.

$$L_{t+1} = \exp\{-\sum_{k=1}^{65-n} r_{t+k}\}\,(\bar{a}_{\overline{15}|} + {}_{15|}\bar{a}_{65})$$

With regard to the *real* interest rate risk during the accumulation phase of the elder generations, the most conservative stance would be assuming $r_{t+k} = 0$ for all $k = 2, 3, \cdots$. Under such a mindset, the hedging portfolio would become age-independent and composed of *nominal* government bonds with the duration equal to that of the annuity $\bar{a}_{\overline{15}|} + {}_{15|}\bar{a}_{65}$ since the participant has to give up the idea of preserving the *real* values of annual pensions after annuity conversion.

On the other hand, Koijen, Nijman and Werker [2007] shows that the hedging portfolio for generations close to the annuity conversion to *nominal* annuities includes long position of 3-year *nominal* bonds and short position of 10-year *nominal* bonds for the purpose of hedging their exposure to *real* interest rate risk before the annuity conversion. However, it is needless to say that the actual hedging portfolio depends on the preference of the participants and they are not always rational. For instance, if the participants are concerned only about the *nominal* values of their accounts immediately before the annuity conversion and not concerned about the *real* value of the annual pensions, then the hedging portfolio would be composed of zero coupon *nominal* bonds with maturities equal to the periods until the annuity conversion.

It might be possible to understand the reason why ordinary participants in Japan are so much concerned about the *nominal* values of their accounts as follows. Namely, if participants can restrict the range of the market shocks to which they give consideration to sudden market depreciation and decline in the market *nominal* interest rates and exclude the risk of increases in the salary index and the price index, then the question becomes how to preserve the *nominal* values of annual pensions. Besides, since increases in the price index are often accompanied by rises in *nominal* long-term interest rates, preserving the *nominal* values of the accounts is expected to provide certain protection against inflation risk during the periods until annuity conversion. Of course ordinary participants well understand that preserving the *nominal* values of pensions or the *nominal* values of the accounts is not an optimal strategy. However, when the possibility of large increases in the salary index looks scarce for the time being, ordinary participants thus prefer preserving *nominal* values rather than *real* values of pensions or the accounts.

In such a case that the hedging portfolio of elder generations is composed of long positions of government zero coupon nominal bonds or TIPS with appropriate maturities, then we can introduce a mechanism of virtual borrowing and lending of the hedging portfolio of the elder generations between the younger and the elder generations. This mechanism actually means reallocating investment returns between the two generations. Here, the duration of the hedging portfolio of the elder generations would be equal to that the average remaining periods until the age of annuity conversion, the duration of the annuity $\bar{a}_{\overline{15}|} + {}_{15|}\bar{a}_{65}$ or the sum of the two. If the younger generations are facing the budgetary constraints with regard to the weight of the speculative portfolio (namely, when the relative risk aversion γ of the younger generations is less than 1 and the ideal weight of the speculative portfolio becomes greater than 100%), this mechanism of virtual borrowing and lending of government bonds between the younger and the elder generations provides the younger generation with the opportunity to overcome the budgetary constraints, while holding short position of the government bond portfolio.

In a pure DC plan the younger generations are usually not able to hold such leveraged positions because of the budgetary constraints. However, in a Nursery plan the younger generation is able to hold such leveraged positions through the borrowing of a portion of the bond portfolio from the elder generations. Annually the younger generations shall pay the amounts corresponding to the bond portfolio returns to the elder generations. On the other hand, there is also an advantage for the elder generations that there is no need of actually purchasing bonds from the market and composing and managing the portfolio. Thus the younger and the elder generations are both able to reduce the investment costs through this mechanism of virtual borrowing and lending of the hedging portfolio.

It might be felt that the leveraged position of the younger generations is too risky. However, economically there is no substantial difference between this return reallocation mechanism and the traditional risk-reward structure of DB plans. In a ‘traditional’ DB plan, the plan assets are collectively invested in a portfolio which is common to all generations including beneficiaries, whereas the beneficiaries do not share any investment risk as far as their nominal amounts of benefits are concerned. Economically, this is equivalent to the situation that the active lives borrow the reserves from the beneficiaries, combine the principal with their own assets and invest them in the common portfolio (policy asset mix), while paying the ‘interests’ corresponding to the expected rate of return on investments to the beneficiaries. The younger generations of a Nursery plan might be less risky than those of comparative ‘traditional’ DB plans, since in a Nursery plan the accumulation component is insulated from the financial risks in the payout component.

3.2 Risks at annuity conversion

As explained in section 3.1.2, interest rate risk for the participants at annuity conversion can be overcome by appropriate investment strategies during the accumulation phase. The essential point here is the structure of the hedging portfolio. Investment risks during the accumulation phase should be recognised and measured in comparison to the initial liabilities immediately after the annuity conversion. Here the initial liability means the economic value of the annuity with the targeted amount of annual pensions.

In section 2.1 we have assumed that the balances of the individual accounts are unanimously converted to annuities at the predetermined age. However, practically the plan may be required to provide the participants with the opportunity of selecting the age of annuity conversion. Namely, each participant is allowed to select the most appropriate age at which the balance of her account is converted to annuity out of the predetermined 'annuitisation period,' for instance, from age 60 to 69. In such a case, the relative risk aversion of the participants whose ages are close to or in the 'annuitisation period' may not be infinite. Then the corresponding lifecycle funds would have positive weights with regard to the speculative portfolio even during the 'annuitisation period.' It is therefore supposed to become inevitable for the plan to provide each participant with the opportunity of selecting the weight of the speculative portfolio by her, if she is given an opportunity of selecting the age of annuity conversion.

3.3 Risks in the payout component

3.3.1 Optimal age from which longevity risk is shared among participants

As mentioned in section 2.3.3, if a participant dies after the annuitisation age 65 but before attaining the predetermined age $65+m$ at which the guaranteed period ends and from which *personal* longevity risk is pooled among the participants, she (or her family) will entirely lose the amount allocated for covering *her* longevity risk. For the participants especially with bequest motives, these 'losses' would be recognised as a major drawback of annuity conversion. However, if we make the guaranteed period longer, the amounts of annual pensions become smaller. In other words, the amounts of the annual pensions are in a relation of trade-off to the amounts of 'losses' caused by the annuity conversion. Then such a question would arise how much ratio of the balance should be allocated for covering *personal* longevity risk, while ensuring steady annual pensions.

Generally speaking, if a person wants to insure *his/her* longevity risk without purchasing life annuities, he/she has to construct a bond portfolio which secures the steady cashflows that will cover his/her remaining life in almost all cases. Namely, the self-insurance cost for covering *personal* longevity risk is the present value of the annuity certain with the payout period of, for instance, 40 years for male and 45 years for female, when the person is 65 years old[2]. On the other hand, the person can insure *his/her* longevity risk by purchasing a life annuity with or without a guaranteed period. Namely, the insurance cost for covering *personal* longevity risk with a life annuity with guaranteed period *m* is equal to the economic value of the annuity concerned. The guaranteed period *m* depends on the risk aversion of the annuitant with regard to the annuitisation 'losses.'

The self-insurance cost is of course more expensive than the insurance cost. The ratio of the difference between the self-insurance cost and the insurance cost to the insurance cost is called a *spending improvement quotient* (Scott [2007]). Economically, a participant can release the money equal to the *spending improvement quotient* multiplied by the amount of the balance at the time of annuitisation, by investing the amount in the annuity instead of constructing a self-insurance portfolio.

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[2] It is estimated that the probability that a male belonging to the Japanese cohort with birth year 1947 and aged 65 will survive over 40 years (beyond age 105) is less than 1%, while the probability that a female belonging to the same cohort aged 65 will survive over 40 years is around 3%. So we extend the payout period by 5 years for females. Then the probability that the female will survive over 45 years (beyond age 110) becomes less than 1%.

$$\text{Spending Improvement Quotient} = \frac{\text{Self - insurance cost} - \text{Insurance cost}}{\text{Insurance cost}}$$

$$= \frac{\bar{a}_{\overline{n}|} - (\bar{a}_{\overline{m}|} + {}_{m|}\bar{a}_{65})}{\bar{a}_{\overline{m}|} + {}_{m|}\bar{a}_{65}}$$

Here, n denotes the length of the payout period of the annuity - certain, and m denotes the length of the guaranteed period of the life annuity.

On the other hand, as noted above, if an annuitant dies during the guaranteed period, she will entirely lose capital equivalent to the present value of the simple life annuity starting at the end of the guaranteed period (which is equal to the cost of immediately purchasing a deferred annuity). Let us call the ratio of the present value of this deferred simple life annuity starting at age $65+m$ to the total present value of the life annuity with the guaranteed period a *lost control quotient*. Economical meaning of a *lost control quotient* is, in the context of this section, the amount of which the participant has lost control by converting one unit of capital into the annuity with the guaranteed period, measured at the time of the annuitisation.

$$\text{Lost Control Quotient} = \frac{\text{Insurance cost} - \text{P.V. of the annuity - certain}}{\text{Insurance cost}}$$

$$= \frac{{}_{m|}\bar{a}_{65}}{\bar{a}_{\overline{m}|} + {}_{m|}\bar{a}_{65}}$$

Then it can be said that the optimal age $65+m$ from which *personal* longevity risk should be pooled is the age that maximises the residual that is left when the *lost control quotient* is subtracted from the *spending improvement quotient*, on condition that the deferred simple life annuity starting at $65+m$ is categorised as longevity insurance (namely, the capital is not returned when the person dies during the deferred period). See Antolin, Pugh and Stewart [2008].

The following two tables show that the optimal ages from which the longevity risk should be pooled among participants are, 84 for the Japanese male cohort with birth year 1947, and 91 for the female cohort with the same birth year, on the assumption that the expected *nominal* interest rate is 1.5% p.a. Here, the expected life at birth is 80.68 years for the male cohort, and 88.09 years for the female cohort. The *nominal* discount rate of 1.5% p.a. may look extremely low but fits the current financial situations in Japan. The expected remaining lives at age 65 are 20.37 years for the male cohort and 25.81 years for the female cohort. Therefore, it can be said that, on the assumption that the expected *nominal* discount rate is 1.5% p.a., *personal* longevity risk should be insured against survivals beyond the expected period of life at the normal retirement age. This result seems consistent with the arguments that policy makers should consider mandating deferred life annuities that start at very old ages (Antolin [2008]).

Table 1　The optimal age from which longevity risk is pooled for Japanese *male* cohort with birth year 1947

① Starting age of the simple annuity	80	81	82	83	84	85	86	87	88	89	90
② PV of the annuity（=③+④）	18.64	18.88	19.14	19.43	19.73	20.06	20.41	20.79	21.19	21.60	22.04
③ （Annuity certain）	13.42	14.21	14.99	15.76	16.52	17.26	18.00	18.73	19.44	20.14	20.84
④ （Simple life annuity）	5.22	4.67	4.15	3.67	3.22	2.80	2.41	2.06	1.75	1.46	1.21
⑤ Amount of the annuity	536	529	522	514	506	498	489	481	472	462	453
⑥ Amount of a simple annuity starting at 65	585	585	585	585	585	585	585	585	585	585	585
⑦ Decrease due to the annuity certain	8.3%	9.5%	10.7%	12.1%	13.4%	14.8%	16.3%	17.8%	19.4%	20.9%	22.5%
⑧ Lost control quotient	28.0%	24.7%	21.7%	18.9%	16.3%	13.9%	11.8%	9.9%	8.2%	6.8%	5.5%
⑨ PV of a 40 year annuity certain	30.08	30.08	30.08	30.08	30.08	30.08	30.08	30.08	30.08	30.08	30.08
⑩ Spending improvement quotient	61.4%	59.4%	57.2%	54.9%	52.4%	49.9%	47.4%	44.7%	42.0%	39.2%	36.5%
⑪ ⑩−⑧	33.4%	34.6%	35.5%	36.0%	36.2%	36.0%	35.5%	34.8%	33.8%	32.5%	31.0%

Table 2　The optimal age from which longevity risk is pooled for Japanese *female* cohort with birth year 1947

① Starting age of the simple annuity	85	86	87	88	89	90	91	92	93	94	95
② PV of the annuity（=③+④）	22.37	22.56	22.76	22.99	23.24	23.51	23.80	24.12	24.46	24.82	25.22
③ （Annuity certain）	17.26	18.00	18.73	19.44	20.14	20.84	21.52	22.19	22.85	23.51	24.15
④ （Simple life annuity）	5.10	4.56	4.04	3.55	3.09	2.67	2.28	1.92	1.60	1.32	1.06
⑤ Amount of the annuity	447	443	439	434	430	425	420	414	408	402	396
⑥ Amount of a simple annuity starting at 65	476	476	476	476	476	476	476	476	476	476	476
⑦ Decrease due to the annuity certain	6.1%	6.9%	7.7%	8.6%	9.6%	10.6%	11.7%	12.9%	14.1%	15.4%	16.7%
⑧ Lost control quotient	22.8%	20.2%	17.7%	15.4%	13.3%	11.4%	9.6%	8.0%	6.6%	5.3%	4.2%
⑨ PV of a 45 year annuity certain	32.73	32.73	32.73	32.73	32.73	32.73	32.73	32.73	32.73	32.73	32.73
⑩ Spending improvement quotient	46.3%	45.1%	43.8%	42.4%	40.9%	39.3%	37.5%	35.7%	33.8%	31.9%	29.8%
⑪ ⑩−⑧	23.5%	24.9%	26.1%	27.0%	27.6%	27.9%	28.0%	27.8%	27.3%	26.6%	25.6%

(Note) Expected mortality rates are those of the cohorts with birth year 1947, based on the "2006 Estimation of Future Population of Japan," by the National Institute of Population and Social Security Research (IPSS). It is assumed that the expected *nominal* interest rate is 1.5% p.a.

3.3.2 Risk margin to be charged in the process of annuity conversion

The liabilities of a Nursery plan are much less uncertain than those of traditional DB plans and therefore easy to estimate. Besides, when the normal retirement age is 65, the duration of the benefit cashflows is 40 years at the maximum, which is much shorter than those of traditional DB plans. The hedging portfolio can thus be easily constructed and managed without the help of swap contracts or other derivative instruments. There is no need of outsourcing the investment management of payout component to external financial institutions. This should be recognised as one of the major advantages of a Nursery plan that severs the accumulation phase financially from the payout phase.

There would remain three major risks in the payout component that could not be ignored, even if so-called immunisation strategies were implemented. First one is the interest rate risk at annuity conversion. At the annuity conversion the long-term market interest rates may deviate from the assumed discount rate. Second one is the investment risk during the payout phase. We have to admit a certain range of tracking errors with regard to the implementation of immunisation strategies. Third one is *macro* longevity risk during the payout phase. Actual mortality rates of the participants may improve as a whole beyond the expectations on which the annuity conversion rates are constructed.

It is thus indispensable that a small but sufficient percentage of risk margins have to be charged in the process of annuity conversion. But charging excessively burdensome risk margins do not suit the interests of the participants, especially those who will die at an early stage after retirement. It is therefore recommended that some *ex-post* adjustment mechanisms should be incorporated into the plan *in advance*, in order to lessen the required risk margins and ensure trusts of the participants to the plan. "With profits and losses" annuities or annuities with some variable benefit portion may be the candidates of the *ex-post* adjustment mechanisms.

4 Conclusion

Until now (September 2009), there exists only one example of a Nursery plan in Japan. This plan has been implemented since 2002. With regard to the National Farmers Pension Fund (NFPF), after the collapse of the old scheme, a new funded scheme was created in 2002, adopting a Nursery plan structure. The old scheme could not endure the steep decline in agricultural population in Japan since the old scheme was financed on a pay-as-you go basis. The new scheme was designed so as to reduce the risks of the plan (not of the participants) as much as possible. However, it is seemingly still in its infancy since there are many fundamental issues to be addressed such as investment management for both the accumulation and payout components, appropriate risk margins at annuity conversion and measures for mitigating the market shock risks for the generations close to annuity conversion that has become evident during the current world financial crisis.

Very recently, a mechanism of levelling off the imbalances among generations has been introduced to the NFPF in 2009. This mechanism aims at making up for the cumulative capital losses (if any) in individual accounts immediately before the normal annuitisation, as much as possible, at the expense of a small portion of annual investment income of all participants throughout their accumulation phase. Although this mechanism is still in a very primitive stage and such an essential problem remains to be resolved as how much percentages of investment income should be reserved for preparing the risk of possible cumulative capital losses, it represents an eloquent proof of the absolute need that appropriate risk-sharing mechanisms should be incorporated in this DC-like hybrid plan.

Considering that the actual new NFPF scheme is still in its infancy, this paper assumed a stylised Nursery plan and proposed several measures to mitigate the risks and drawbacks of this DC-like hybrid plan. Especially, this paper introduced a levelling off function of the imbalances of the 'funded' status among generations, through an economically fair trade between each participant and a special buffer fund. This paper also proposed a mechanism of reallocating investment returns among participants, assuming intergenerational relationships of virtual borrowing and lending of capital, in order to overcome the budgetary constraint of young generations, mitigate market shock close to annuity conversion, and reduce overall investment costs. Furthermore, this paper devised the optimal age from which *personal* longevity risk should be pooled among participants in the payout phase, based on quantitative evaluation of both the pros and cons of annuitisation, namely improving the spending of the participants and stripping the control of the participants with regard to the capital allocated for pooling *personal* longevity risk.

From these considerations it is suggested that well-designed inter/intra-generational risk-sharing can make good the inherent shortcomings of DC-like hybrid plans to some extent and thus enhance the welfare of participants without exposing each generation to unaffordable risks. If we expect CDC or DC-like hybrid plans to play a reliable role in the overall old-age income security system, it is indispensable that these plans are equipped with appropriate inter/intra-generational risk-sharing structures and mechanisms.

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