Occupation Pension for Public Employees in China: A New Approach with DB Underpin Pension Plan

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Abstract

The population aging has already become a major concern in China's pension system, and the risk is expected to increase rapidly in the future. As a result, the current Pay-as-you-go pension system will not be sustainable and major revision of plan design remains an urgent problem to tackle. The State Council announced the reform plan for public employees in January 2015, officially disclosing that the social pension systems for private and public employees shall unify. Our proposed occupation pension plan for public employees is one of the important components in transiting from a dual-track pension system to a sustainable and unified system. We aim at providing a pension design, i.e. the DB underpin pension with estimates of the costs and benefits. We have used the financial engineering approach to calculate the hedge contribution for a DB underpin hybrid pension plan benefit. We also treat pension benefit and salaries in aggregate. Therefore, the real salary model is constructed stochastically and exogenously. Employees' total benefits could be determined by multiple factors, such as inflation, economic environment, and employer's preference. However, the expectation of employees' total benefits

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should not be affected by the change of salary and pension benefits. Our results could facilitate the ongoing pension reform in China, providing rigorous benchmark with public policy implications as to plan design, cost estimation, as well as risk management approach.

1 Introduction

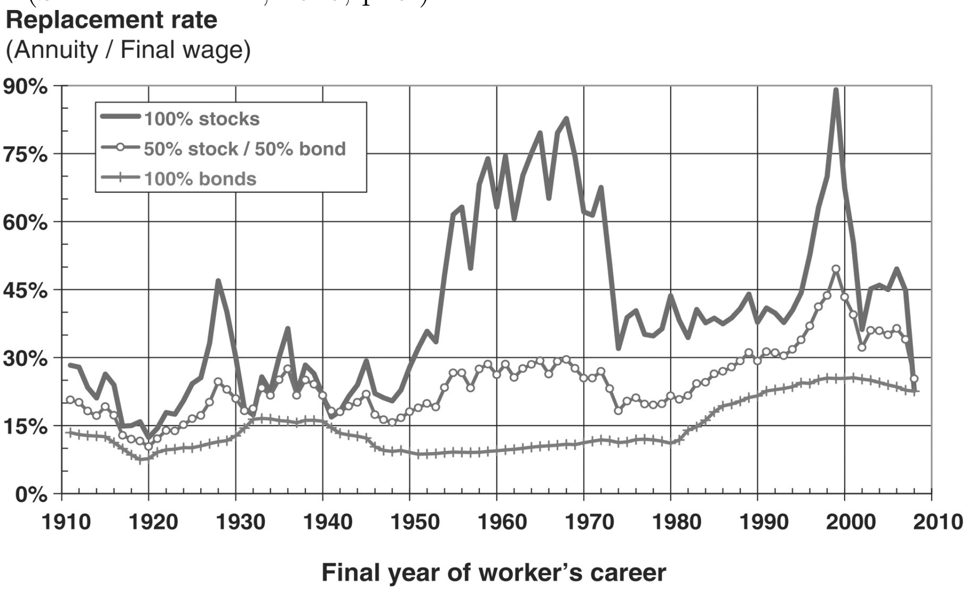
The social pension systems for employees working in public versus private sectors are quite different in China. Without paying any explicit contribution in salary, employees in the public sector can enjoy a replacement ratio as high as 80% at retirement through a pension program sponsored by Chinese government. In contrast, there are only very limited number of private employers in China providing comparably generous pension plan for their employees. Even if the plan was made available, the employees working in the private sector usually need to pay contribution equals to 28% of their salary for the social security. This inequality, known as the 'dual-track pension system' has been attacked and discussed for years by both academics and practitioners, yet it is announced recently that the 'dual-track pension system' era is about to end. The State Council announced the reform plan for public employees in January 2015, officially disclosing that the social pension systems for private and public employees shall unify. In specific, public employees are required to pay a contribution equals to 4% of their salary, and their employer shall match additional contribution equals to 8% of the salary base, in order to establish an employer sponsored pension plan, known as occupation pension.

The detailed design of this occupation pension is not finalized yet. As we know, defined contribution (DC) plan would expose employees to undesirable investment risk, while defined benefit (DB) plan could expose employers to financial burden in plan funding. In China, both DB plans and DC plans are on the discussion table. Proponents of DB plans state that DB plans are the only way that can provide participants retirement guarantees. On the other side, proponents of DC plans battle that DC plans are more secure since employees actually know what happens in their individual accounts with their own contributions. In the past few years, we are experiencing a rapid converting from DB plans to DC plans all over the world. Most reasons are that DB plans are too expensive in administration costs and are difficult in communication with participants. DC plans can provide a upside potential on employees' retirement benefits. However, the individual retirement account value highly depends on the long-term investment result by employees. We must aware that these plans are not just ordinary savings account with tax deferral. Most importantly, they are for the purpose of providing retirement incomes. Therefore, DC plan sponsors must analyze in the context of the amount of lifetime retirement income they can provide, and also consider how risks are distributed between employees and employers. Under a classic DC plan, employees should carries most risks, such as investments risk, inflation risk, interest risk, and longevity risk. Usually, employees can not manage all risks very well. That may cause the inadequacy of employees' retirement benefits and the associated inequities in DC pensions arising from accidents of retirement timing.

In China, the average salary for public employees are lower than the average salary for prive employees. They used to have higher retirement benefits to balance the lifetime income. The reform plan for the occupation pension system should consider this factor. The new occupation pension plan must also balance the potential growth on retirment income and risks caused by the pension plan. Although, proponents of DC plans always claim that DC plans can provide a higher replacement ratio - retirement income relative to final salary at the time of retirement- for employees than DB plans, many recent researches show the performance of DC plans are not ideal. Burtless(2010) shows that DC plans have very volatile performance. Given the contribution rate is 4% of salary and 40 years of service, the replacement ratio at retirement is between 12% to 89%. The average replacement ratio has averaged 49% for employees retiring after 1945. Although employees can construct their investment portfolio with some less volatile investments such as government bonds, the replacement ratio also decreases while the volatility decreases. As shown in Figure 1, the average replacement rate under a complete stock investment strategy is 40%. After employees choose some less risky investment strategy, the average under the half stock and half bond strategy drops to 24%. The average is only 14% under a complete bond strategy. Under a traditional DB plan, such as US social security pension, the replacement ratio is more stable and predictable. According to the estimate by the Social Security Actuary, the inflation-adjusted replacement ratio for employees with an average lifetime earnings is between 42% to 46%. Employees with lower-than-average salaries can even have a higher replacement ratio. (Clingman et al. 2008)

A pure DC plan put all investment risk on employees' shoulders. However, most

Figure 1: Replacement rate obtained from personal account savings of workers who invest in alternative portfolio and contribute 4% of annual salary over a 40-year career. (Source: Burtless, 2010, p15.)



of them can not handle it well, especially in a period of financial crisis and low interest rate environment. For public employees, they even need more protection at retirement because of their lower salary during working time. Many actuaries are trying to explore a new pension system than maximize advantages of DB plan and DC plan to all participating parties, but lowers their disadvantages. Therefore, we propose a DB underpin pension hybrid plan, adopted by some public employers in Europe and North America. The DB underpin pension system will neither be DB plan or DC plan. This plan offers benefits for which investments risks are distributed to both employers and employees. It maybe one of the best options. Employees are looking for higher benefits with guarantees. Plan sponsors should think of the balance between benefits and guarantees. The DB underpin pension plan, which is a DC plan with a guaranteed DB underpin, known as a floor-offset plan in the United States. In such a plan, employees still pay their defined contribution to an individual account as a standard DC plan. At retirement, the balance of individual account will be annualized and be compared with a DB benefit based on the accrual rate and years of service. If the DB benefit gives a higher pension, this is the pension that the employee receives. It is relatively rare that this occurs. Chen and Hardy(2009) use a financial engineering way to calculate the cost of such a pension plan. They find the Traditional Unit Credit (TUC) funding method provides a better way to fairly valuate the price of DB underpin guarantee and also generates an intuitive and attractive funding patterns.

In this DB underpin pension plan, the value of providing the guarantee is similar to the price of an European type put option, where the strike price is the DB guarantee. To keep the DB guarantee, employers should pay hedge contributions according to hedging strategies. If we consider the DB guarantee as the insurance on the pension benefit, the hedge contribution is the monthly premium. In this paper, we will discuss the selection of the DB guarantee and its connection with costs. A standard DB guarantee is based on the accrual rate, years of service, salaries and annuity factor after retirement. A higher accrual rate will cause a higher DB underpin guarantee and a higher hedge contributions. In the plan design stage, plan sponsors should explore the trade-off to find a balance between an appropriate DB guarantee with a reasonable volatility and hedge contributions.

In Section 2, we illustrate one of hybrid pension plans, the DB underpin pension plan, which combine both characters of DB plans and DC plans. In Section 3, we list the major assumptions and the main approach to calculate extra hedge contributions. We use the Traditional Unit Credit method in Section 4 to demonstrate some numerical results under a simple assumption of salary growth. In Section 5, we modify the model of salary growth process and introduce the "pseudo-salary" process to re-calculate hedge contributions. We also discuss the trade-off between the accrual rate and hedge contributions. Finally, we summarize the results and discuss whether this plan is suitable for the China's public employees in Section 6.

2 A DB Underpin Pension Plan

In general, DB plans provide a specific benefit at retirement for each eligible employee, while DC plans specify the amount of contributions to be made by the employer toward an employee's retirement account. In a DC plan, the actual amount of retirement benefits provided to an employee depends on the amount of the contributions as well as the gains or losses of the account. Each plan type has advantages and disadvantages, so an employer or a plan sponsor may want to combine the advantages of each type of plan, such as the ease of communication of a defined contribution plan coupled with employer's assumption of investment risks and rewards in the defined benefit plan. Hybrid plans attempt to combine the advantages of each of pure types of plans into a single plan.

A particular DB underpin pension plan which offers "greater of" benefits and which has not been discussed extensively in the academic literature. This DB underpin pension plan offers a defined contribution benefit with a guaranteed defined benefit minimum underpin. Employees in this plan have their own DB and DC accounts. The pension benefit at exit, such as retirement, death and disability, is determined by the maximum of DB and DC accounts. Britt(1991) and Sherris(1995) discuss the features and more details of this pension plan in Australian retirement funds. This DB underpin plan has been also provided by a number of large public employers in Canada, such as York University and McGill University.

In the York University design, the employee and employer contribute to the employee's money purchase component account (MPCA). At retirement, the York University pension plan provides the employee with the greater of the pension provided by converting employee's MPCA balance to an annuity, which is determined by the current actuarial factors, and the pension provided by the minimum guaranteed benefit formula, which is similar to a DB benefit with average accrual rate of around 1.6%. This plan provides some DC plan advantages as any amounts from a previous employer, together with credited interest, can be easily credited into the MPCA. It also allows members to participate in the upside of the DC plan where the investment experience is favorable. Meanwhile, the DB minimum guaranteed benefit offers the employee some downside protection in fairly extreme investment scenarios. The MPCA is administered by employers and employers will pay non-reduction reserve contributions to the MPCA, in order to provide the guaranteed pension benefits. This non-reduction reserve contribution can be considered as the cost of providing the DB underpin. These contributions are usually evaluated using traditional actuarial methods, supplemented with deterministic or stochastic scenario testing. In this paper, we have used a simplified version of the York University design in the examples and propose a method for recognizing the minimum benefit as an option. We use financial theory to value and hedge the option under some fairly idealized assumptions.

3 Model Assumptions

We will use similar notations as Chen and Hardy (2009), except that we consider the final average DB benefit instead of final salary DB benefit. In a DB underpin pension plan with a guaranteed final average DB benefit, we will calculate the excess of the DB guarantee over DC benefit. For an employee who enters the pension plan at age xe and will exit the plan at age xr (for simplicity, we assume that there are no early exits between entry and retirement), he(or she) will have two pension accounts, DB account and DC account.

We treat the hedge interval monthly, since salary is paid every month. Then, the value of DB account at retirement time $T = 12(xr - xe)$ is denoted as DB_T, which is based on the accrual rate, years of service, final average salary, and annuity value at retirement. For example, we have

$$\mathrm{DB}_T = \alpha\,(T/12)\,S_T^a a_{xr} \tag{1}$$

where α is the DB accrual rate per year of service, S_T^a is the final average salary per annum, and a_{xr} is the value at retirement of an annuity of 1 per year paid according to the pension plan rules. In the following sections, we assume that the annuity value is fixed.

The value of DC account is accumulated by monthly contribution, for $0 \leq t < T$. Therefore, let DC_t denote the value of DC account at time t, where,

$$\mathrm{DC}_t = \sum_{j=0}^{t-1} 2cS_j \frac{A_t}{A_j} \tag{2}$$

where c is the monthly contribution rate paid by employees, and employers match contributions dollar for dollar. The stochastic process A_t represents an accumulated index value at time t for \$1 investment at time 0. The process S_t is employee's monthly salary.

Hence, the guaranteed payoff of such a DB underpin pension plan at retirement is

$$\max(\mathrm{DB}_T, \mathrm{DC}_T) = \mathrm{DC}_T + \max(\mathrm{DB}_T - \mathrm{DC}_T, 0)$$

that is, the maximum of the value of DB and DC accounts. At retirement, an employee will receive the DC account value, plus the amount sufficiently to pay the additional pension to make the total pension up to the DB level when necessary. The payoff of DB underpin option is known as a Margrabe (1978) option, which offers the higher of two risky assets. However, both assets, DB_T and DC_T, both depend on the underlying salary process. It is quite complicated to use the standard valuation method to calculate the value of the guarantee, even with very simple assumptions for the underlying processes.

Another difficulty is that the real salary growth rate process is hard to calibrate. Although many literatures assume the salary process follows a well developed process and is determined by the historical data, such as Sherris (1995), and Cairns (2006), there are many adjustments which are made by employers. Employers should be able to control the salary growth based on multiple factors, such as, expectation and utility, the economic environment, and the aggregate employees' benefits.

In this paper, we consider an extra process which is the total benefit for employees, such as real salaries, pension contributions, and pension guarantees. This process, so called pseudo-salary process S_t^*, is combined by the salary, the employer matched pension contribution and the DB underpin guarantee costs, i.e.

$$S_t^* = S_t + cS_t + G_t \tag{3}$$

where c is the matched contribution rate paid by employers, and G_t is the accumulated hedge contributions.

We introduce the pseudo salary process to fix the exogeneity of salary growth. The annual growth rate of salary for public employees is usually a sensitive topic in China, probablly in other countries too. Public expect the transparency of the compensation system for public employees, especially salary levels. Therefore, the choice of annual salary growth rate for public employees is better to be exogenous. We hereby assume that the total employee benefits include the salary, the employers' contribution to the pension account, and the DB underpin pension guarantee process, G_t. Employers have the expected total benefit for employees. When the DB underpin pension guarantee is in-the-money, employers need to pay more for the DB underpin pension guarantee or the pension benefits. So that they will reduce the employees' salary growth rate to balance the total employees' benefits. On the opposite, if the DB underpin pension guarantee is out-of-the-money, employers do not spend more money for the DB underpin pension guarantee. The salary growth rate is comparable/slightly higher than employers' expected salary growth rates.

In the following sections we use a financial engineering framework and a conventional pension funding approach to value the DB underpin guarantee based on this new process.

Since the DC fund is usually constructed by indexes, equities and bonds, we assume it is a traded asset and is valued by an underlying asset. We assume that the monthly DC fund return follows a lognormal process with annual volatility $\sigma_a = 0.2$ per year, corresponding to the volatility of a balanced fund with mix of equities and bonds. The numerical examples are based on a DC plan with a total DC contribution rate of 10% of salary and half of them is paid by employers, i.e. 5% of salary. We assume the annuity factor at retirement is 10.0. We assume a constant risk free rate of $r = 5\%$ per year continuously compounded.

4 Traditional Unit Credit Approach

Chen and Hardy (2009) shown that the traditional unit credit (TUC) funding principle offers the best approach to fair valuation among the entry age normal (EAN) funding principle, the projected unit credit (PUC) funding principle, and the traditional unit credit (TUC) funding principle. The TUC funding principle generates a reasonable funding pattern for the DB underpin guarantee. The expected average price of the guarantee using the TUC approach has attractive and intuitive features. It is also consistent with the current contributions in force.

Under the TUC approach, the fair valuation does not expect any salary increase. This is philosophically consistent with the accrual approach, in that we do not fund or hedge any benefit until it has accrued. The TUC approach recognizes that salaries are under the control of the employer, and also recognizes the employer option to freeze the plan at current salary levels. In an final average salary pension plan, the number of average years can vary. To test the effect of different averaging periods, we consider 3-year average, 10-year average, and career average as short period scenario, medium period scenario, and long period scenario.

Meanwhile, we use annual salary growth, while salaries and pension contributions are paid monthly. In the beginning of the year, employers will decide the salary growth rate based the aggregated employees' benefits, which includes the real salary, employers' pension contribution, and DB underpin pension guarantee. The real salary level will not change during the year until the beginning of the next year. Employers and employees both pay the monthly contributions based the current salary level. Employers also balance the DB underpin guarantee every month. At time t, the total accrued guarantee liability with value is:

$$H(t) = E_Q \left[e^{-r(T-t)} \max \left(\mathrm{DB}_t - \mathrm{DC}_t \frac{A_T}{A_t}, 0 \right) | \mathcal{F}_t \right] \tag{4}$$

where the value of DB account DB_t and the value of DC account DC_t are defined in equation (1) and (2), respectively.

Since we consider the annual salary growth, the salary only grows in the beginning of the year. So that the monthly contributions during the entire year are same and the salary will not change, i.e. $S_{12j} = S_{12j+i}, j = 0, 1, 2, \cdots, i = 0, 1, 2, \cdots, 11$.

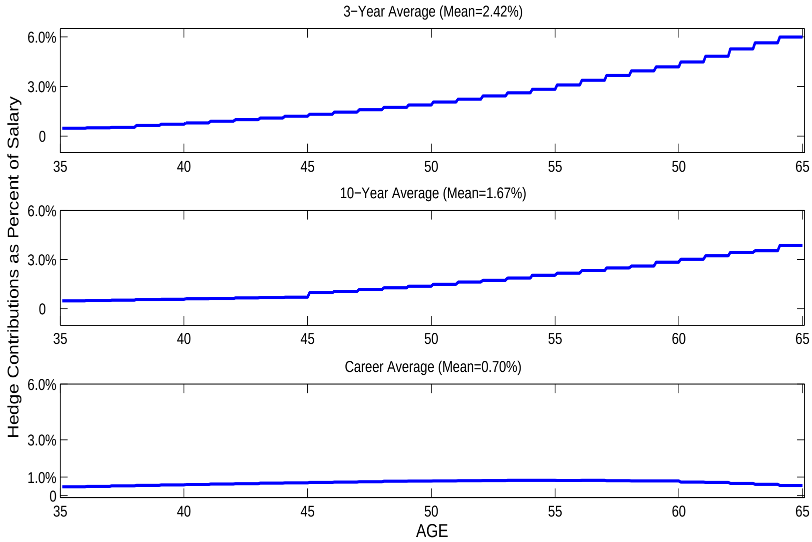
At time t, the value of DB account, DB_t, is known, but the value of DC account $\mathrm{DC}_t \frac{A_T}{A_t}$ is unknown. This payoff is an European type put option with strike price DB_t. We implement the Black-Scholes's formula to find the fair value of the DB underpin guarantee at time t is

$$H(t) = \mathrm{DB}_t e^{-r(T-t)} N(-d_2(t)) - \mathrm{DC}_t N(-d_1(t)) \tag{5}$$

where

$$d_1(t) = \frac{\log \left(\frac{\mathrm{DC}_t}{\mathrm{DB}_t} \right) + (r + \frac{\sigma_a^2}{2})(T-t)}{\sigma_a \sqrt{T-t}}, \quad d_2(t) = d_1(t) - \sigma_a \sqrt{T-t}$$

Figure 2: Comparison of Monthly Hedge Contributions, Entry Age 35



Given the valuation $H(t)$ at time t, the plan actuaries replicate the hedge portfolio by purchasing \$$\mathrm{DB}_t e^{-r(T-t)}N(-d_2(t))$ in zero-coupon bonds maturing at T, and selling \$$\mathrm{DC}_t N(-d_1(t))$ in the DC fund underlying asset.

After one month, at time $t+1$, the hedge account established at time t and brought forward to time $t+1$ has value:

$$Hbf(t+1) = \mathrm{DB}_t e^{-r(T-t)}N(-d_2(t)) \cdot e^{\frac{1}{12}r} - \mathrm{DC}_t N(-d_1(t)) \cdot \frac{A_{t+1}}{A_t} \tag{6}$$

The new hedge costs $H(t+1)$ at time $t+1$, so the cashflow for the DB underpin guarantee is

$$CF(t+1) = H(t+1) - Hbf(t+1)$$

and the hedge ratio as a proportion of salary at time $t+1$ is:

$$cf(t+1)) = \frac{CF(t+1)}{S_{t+1}}$$

4.1 Hedge Contributions under Final Average Pension Plans

In this section, we will show some results under final average pension plans. Assuming real salaries follow a lognormal process with annual volatility $\sigma_a = 0.02$ per year. The accrual rate per year of service is 1.5%.

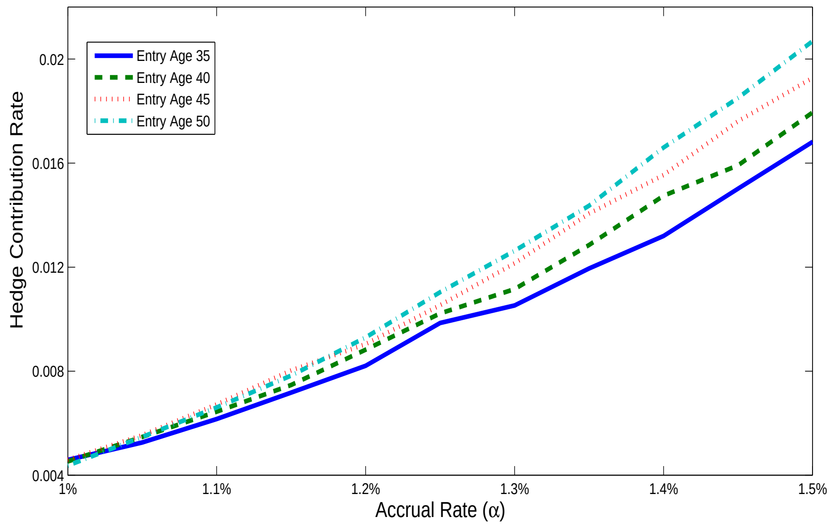
In Figure 2, we plot amortized monthly hedge contributions with different final average pension plans given the entry age 35. Since salaries only change in the beginning of the year, contributions are relatively high because of salary growth and additional month of service. During the year, salaries keep the same and monthly normal costs only credit the extra month of service. In Figure 2, we amortize the hedge contribution with a year to discover the pattern of contributions at different ages. We compare 3-year average, 5-year average, and career average pension plans. The mean of hedge contributions as percentage of salaries drops with longer average period in pension plans. The effect on the price of using 10-year average is significant. The hedge cost is reduced by one third of 3-year average plan hedge cost. The hedge is reduced by two third when career averaging is used.

Another factor that may affect hedge contributions is the accrual rate. The plan sponsors and employers should think of the trade-off between the accrual rate and the hedge contributions. Given the 10-year average pension plan, we plot mean of average hedge contributions in Figure 3 with different accrual rates. When the accrual rate is low, the value of DB account is low. So hedge contributions of DB underpin guarantee are cheaper. The plan sponsors and employers can sacrifices some DB pension accruals to save hedge contributions. For example, for entry age 35, one third accrual rate reduction from 1.5% to 1% can save about three quarters of hedge contributions from 1.7% to 0.45% per salary.

5 The Pseudo Salary Process

As we discussed earlier, pension benefit is only part of employees' compensations. Employers should always think of the balance between salaries and pension benefits. Suppose employers have an aggregate and fixed benefits package for employees,

Figure 3: Comparison of Monthly Hedge Contributions, 10-year Average Pension Plan



which could include employees' salaries, matched pension contributions, and accumulated DB underpin pension guarantees. If an employee receives an extra benefit from one part, for example, salary, he may have to loss some benefits from other parts, such as lower matched pension contribution or low pension benefits.

In this section, we introduce the pseudo-salary process as employers' aggregate benefit package. The growth rate of pseudo salaries is determined by the expected growth of employers. We still assume that salaries only change once a year and consider the total employees' benefit in aggregate. Employers determine the expected "pseudo-salary" process. Let the guarantee process $G(t)$ is the hedge cost cash flow. Therefore, the annual pseudo-salary should be the same as the sum of employees' annual salary, all contributions paid by employers, and hedge contributions for the entire year. At beginning of the each year(i.e. time $12j, j = 0, 1, 2, \cdots$), equation (3) becomes

$$12S^*_{12j} = 12S_{12j} + c(12S_{12j}) + G_{12j}, j = 0, 1, 2, \cdots \quad (7)$$

where the guarantee process is the accumulated hedge cost cash flows,

$$G_{12j} = \sum_{i=0}^{11} [H(12j+i) - Hbf(12j+i)] \cdot e^{r_f \cdot (-\frac{i}{12})},\ j = 0, 1, 2, \cdots$$

Using the TUC funding approach, the hedge account is brought forward using zero-coupon bonds (for the DB side) and the DC underlying asset (for the DC side). So at time t, the value of hedge account before new hedge $Hbf(t)$ does not dependent on the current salary S_t. From equation (5), the value of hedge account after new hedge $H(t)$ does dependent on the current salary S_t. Solving equation (7) numerically, we can find the real salary at time t.

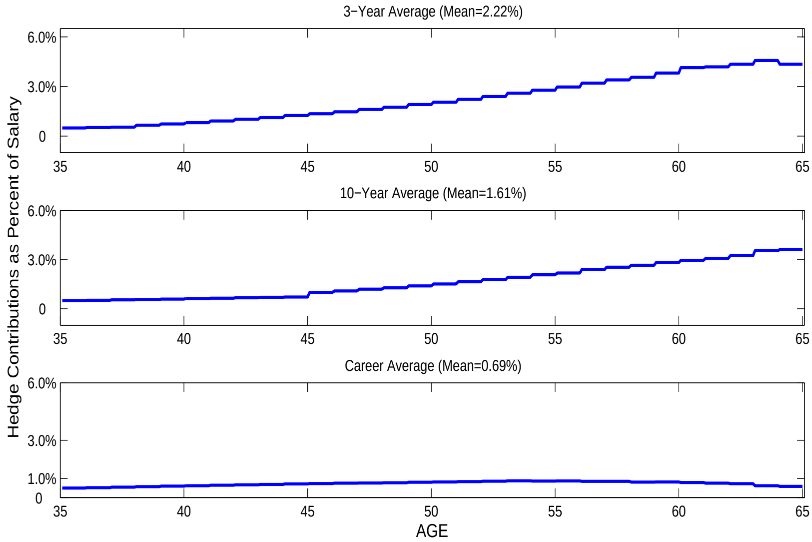
We assume the pseudo-salary process follows a lognormal process. Since the pseudo-salary is the total compensation that employers expect to pay employees, it may be determined by the economy and the inflation, which can be easily captured in the real market. Using the same assumptions and parameters, we can simulate the pseudo-salary process, as well the real salary. In Figure 4, we plot monthly hedge contributions as percentage of salary in different final average pension plans. Hedge contributions are very similar to Figure 2, where hedge contributions are less expensive for long averaging pension plans.

Table 1: Least Square Test using Accrual Rate between 1.0% and 1.5% in a 10-year average pension plan

Entry Age	Slope	Interception	Coefficient of Determination
35	2.3379	-0.01926	0.9933
40	2.6592	-0.02248	0.9935
45	2.9206	-0.02506	0.9920
50	3.3456	-0.02978	0.9865

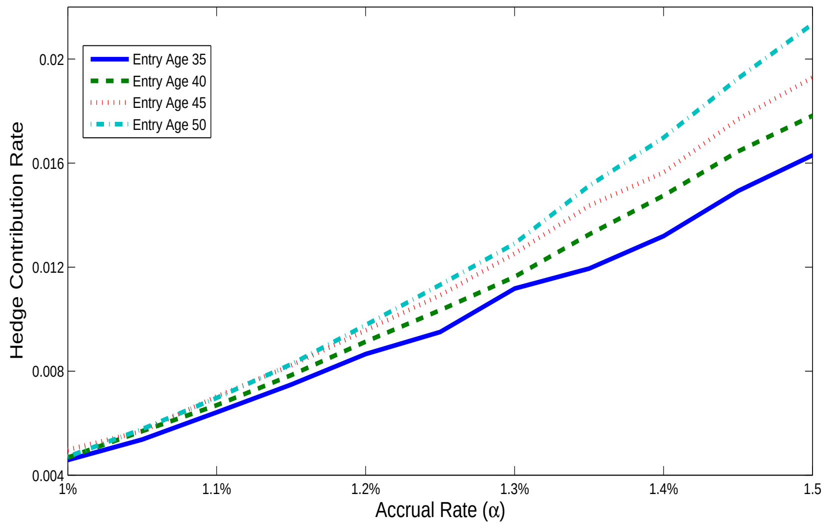
In Figure 5, we plot the effect of the accrual rate for 10-year average pension. It shows that the relationship between the accrual rate and hedge contributions is close to linear. Within the range of accrual rate from 1.0% to 1.5%, the coefficient

Figure 4: Comparison of Monthly Hedge Contributions, Entry Age 35



of determination is almost one under the least square approach. Table 1 shows us the estimated value of slope and interception for different entry ages. The slope is higher for a higher entry age. That means employers and plan sponsors can save 0.33% of hedge contributions if they reduce the accrual rate by 0.1% for older people, for example, who enters the plan at age 50. They can save 0.23% of hedge contributions if the accrual rate is decreased by 0.1% for younger people who joins the plan at age 35. In pension design, employers and plan sponsors may consider different accrual rates for employees in different age groups. A lower accrual rate will cause a possible lower DB underpin guarantee, since it is proportional to the value of DB account. However, Hedge contributions are still lower. From employees' prospective, a higher pension guarantee means a higher extra hedge contributions. The trade-off between the benefits and guarantee should be considered by pension plan designers. Although the accrual rate shows high linear connection with hedge contributions, Figure 5 implies the coefficient of determination decrease for older people. We examine two other extreme cases, where the accrual rate is 0.5% and 2.0%. Table 2 shows us that there is still a linear correlation between the accrual rate and hedge contributions if the accrual rate is high. However, the linearity is

Figure 5: Comparison of Monthly Hedge Contributions, 10-year Average Pension Plan



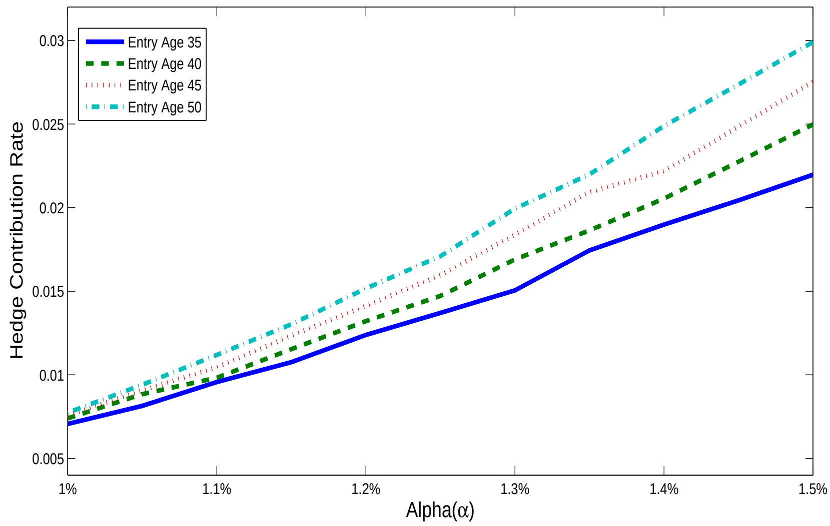
less significant with a small accrual rate.

Table 2: Least Square Test using Different Accrual Rate (α) Range

	Coefficient of Determination	
Entry Age	α between 1.0% to 2.0%	α between 0.5% to 2.0%
35	0.9770	0.8871
40	0.9755	0.8759
45	0.9679	0.8588
50	0.9690	0.8477

In a 3-year average pension plan , we can see the same linear pattern on the accrual rate and the hedge contribution in Figure 6. However, the slope of lines is more steeper in 3-year average pension plan than 10-year average pension plan. For example, for entry age 35, the slope is 2.33 in 10-year average plan against 3.05 in 3-year average plan. Table 3 shows the slopes and interceptions for different entry ages in the 3-year average plan. For a fewer averaging period plan, the sensitivity

Figure 6: Comparison of Monthly Hedge Contributions, 3-year Average Pension Plan



of the accrual rate and hedge contribution is higher. For a 35 years old participant, the average hedge cost is 2.22% of salary if the accrual rate is 1.5%. When it declines 33% to 1.0%, the hedge cost is only 0.7% of salary. That means a higher flexibility for plan sponsors. They can more effectively adjust the accrual rate of pension plans in the design stage to control their hedge risks during the active plan period. Given a fixed hedge contribution rate, such as 1.0%, the accrual rate is around 1.1% in a 3-year average pension plan and is around 1.25% in a 10-year

Table 3: Least Square Test using Accrual Rate between 1.0% and 1.5% in a 3-year average pension plan

Entry Age	Slope	Interception	Coefficient of Determination
35	3.0542	-0.02404	0.9951
40	3.5201	-0.02860	0.9938
45	3.9915	-0.03322	0.9931
50	4.4818	-0.03805	0.9924

average pension plan. Since a pension plan with longer averaging period usually is less volatile on benefits, employees should be rewarded a higher accrual rate in such a plan.

6 Conclusions and Future Development in China

In this paper we have used the financial engineering approach to calculate the hedge contribution for a DB underpin hybrid pension plan benefit. We also treat pension benefit and salaries in aggregate. Therefore, the real salary model is constructed stochastically and exogenously. Employees' total benefits could be determined by multiple factors, such as inflation, economic environment, and employer's preference. However, the expectation of employees' total benefits should not be affected by the change of salary and pension benefits.

A DC plan usually promises higher returns to employees, while a DB plan provides a safety. For public employees in China, they usually need more safety than returens. Therefore, traditional DC plans may not be the best choice. The hybrid pension plan design is particularly attractive to both employers and employees because of the combination of DB components and DC components, which is a suitable design for the occupation pension system in China. In such a plan, employees have a guaranteed retirement benefit with upside potential. This is more valuable in a period of economic uncertainty. For the government, this plan is still a DC plan, where they only have limited responsibilities. Unlike a traditional DC plan, this DB underpin plan offers more flexibility to government regarding plan design. We have shown that the accrual rate and hedge contribution costs are linearly correlated. Government could choose an appropriate accrual rate to control costs. Certainly, we have shown that the trade-off between returns and guarantees exists in a DB underpin pension plan. Government can also control the risks through the salary averaging period. For a short averaging period plan, for example, a 3-year average pension plan, the hedge costs are more expensive, while it offers a higher benefit for employees. Given the same hedge costs for employers, this is also a trade-off between the accrual rate and the averaging period. A longer averaging period plan can offer employees a higher accrual rate with the same hedge costs.

In China, the population aging has already become a major concern, especially for the China's pension system. The solovency risk in China's social pension system is expected to increase rapidly in the future. As a result, the current Pay-as-you-go pension system will not be sustainable and major revision of plan design remains an urgent problem to tackle. The proposed occupation pension plan for public employees is one of the important components in transiting from a dual-track pension system to a sustainable and unified system. We aim at providing a pension design, i.e. the DB underpin pension with estimates of the costs and benefits. Our results could facilitate the ongoing pension reform in China, providing rigorous benchmark with public policy implications as to plan design, cost estimation, as well as risk management approach. In the future work, the connection and the trade-off between benefits and guarantees could be established based on all parties' criteria. When government designs the occupation pension plan, it should think about their risks and returns. Public mployees should also consider the potential growth and the guarantee on their retirement benefits. Some utility function can be introduced in such model to determine the optimal trade-off between benefits and guarantees for pension plan design. In addition, some other risks, such as interest risks and mortality risks, could also be considered in the pension design to solve the trade-off question.

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