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Let Us Trade Pension Claims

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Lead

Trading pension claims would kill many birds with one stone: an accurate valuation of pension liabilities would provide a measurable yardstick for plan managers; beneficiaries would be able to diversify the idiosyncratic risk of their plan sponsors; systematic risk could be reallocated to comply with individual risk/return preferences. The consequence would be an alignment of incentives to fully fund plans, lower agency and governmental bail-out costs, and an increase in general welfare.

Underfunded Pension Plans and the Risks on Pensioners

It is widely believed nowadays that defined pension plans are underfunded. According to Wilshire Associates Research, only 62 of the 331 corporations contained in the S&P500 Index that maintain defined benefit plans had pension assets that equaled or exceeded liabilities in 2003, and the median corporate funded ratio of all 331 firms was 82%. The unfunded portion of a pension plan amounts in many firms to a sizeable fraction of the company's net worth. Even worse, funded ratios for terminating plans are generally much lower. According to the U.S. Pension Insurance Data Book, only 3.3% of claims involved in plans terminating between 1975 and 2003 had a funded ratio of more than 75%, and more than half of all claims faced a funding-level of less then 50% (see table 1). Underfunding has been a problem for a long period of time. Carlson (1974) shows early examples of unfunded liabilities of 46% of equity at Western Union, 53% at Bethlehem Steel and 86% at Uniroyal. After prominent bankruptcies in recent years, the problem has gained attention again and can be spotted among all sizes of plans and plan sponsor's industries. Unless a company is bankrupt, it is obliged to make up for any shortfall in the pension plan. However, in case

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of bankruptcy, the funding level of the plan defines the recovery value for the pension claimants, considering that plan assets serve solely for the benefits of plan participants and that additional recovery value from the company cannot be expected. Clearly, partial default on these obligations is possible.

Moreover, Bulow (1982) argues that employees face significant nonsystematic risk under a projected benefit implicit agreement with the firm, meaning that younger workers accept lower wages in return for an informal agreement that they will be highly paid later in their career. Workers who leave earlier than average subsidize workers who stay longer. Unless the worker's financial well-being is negatively correlated with the tenure at the firm, additional idiosyncratic risk is created, forcing the company to pay higher salaries without reducing its cost of capital.

Default on pension liabilities can have catastrophic impacts on individuals relying on their pension payments. Beneficiaries are exposed to the risk that the sponsor will not make appropriate contributions or will go bankrupt, which they cannot avoid by diversification. So, they bear a large company-specific risk. Members of such schemes are in effect unsecured and off-balance captive lenders to the company.

It is almost impossible to imagine a less suitable investment for them than such a high risk and undiversified claim. Allowing to trade pension claims would enable beneficiaries to exchange their pension claim against a more diversified claim, and even to adjust systematic risk to their individual profiles. The result would be an increase in general welfare. On top of this, trading pension claims in a complete and efficient market would assign a fair value to each claim, establishing a benchmark serving as a yardstick to pension plan managers, allowing to better pursue immunization of assets and liabilities. We propose a flexible and low-cost mechanism for transferring and transforming credit risks, in the form of *a collateralized pension claim obligation* (CPCO).

Table 1: Claims of Terminating Plans by Fiscal Year and Funded Ratio (1975-2003)

	1975-1979	1980-1984	1985-1989	1990-1994
Under 25%	67.7%	41.0%	51.5%	58.6%
25%-49%	21.6%	41.5%	39.8%	11.5%
50%-74%	8.4%	16.0%	8.4%	27.0%
75% and over	2.4%	1.5%	0.4%	3.0%
Total	100%	100%	100%	100%

	1995-1999	2000-2003	Total
Under 25%	13.3%	3.9%	20.2%
25%-49%	23.6%	40.9%	35.0%
50%-74%	43.2%	52.4%	41.5%
75% and over	19.9%	2.9%	3.3%
Total	100%	100%	100%

Source: PBGC, Pension Insurance Data Book 2003

Misaligned Incentives as Root Cause to Underfunding

Defined benefit plans, promising life-long salary based payments after retirement, impose several risks on the company, particularly the risk of salary growth and life expectancy as well as the risk of underfunding when the pension's assets don't meet the expected returns. In order to value its pension liabilities, a firm needs to make assumption with respect to longevity, salary growth and, last but not least, the discount rate. Existing regulation, in conjunction with accounting practices, allow companies to choose these assumptions, and thus the funding level of its plans, to a certain degree. Sponsors decide on the amount of contributions to the pension fund made by the company every year. Casual discussions with practitioners in the field reveal that approximately two thirds of the UK defined benefits pension schemes have the yearly contribution decided by the sponsor, not by a trustee. Furthermore, the pension plan's asset allocation is often determined by the sponsor. In the bull market of the late nineties, pension plans were frequently abused as income generators. Big companies were boosting financial results with pension profits, including General Electric, where the pension plan gains accounted for 9% of operating income in 1999. The unhealthy incentive to increase risk of pension investments resulted in pension funds allocating 67.5% of their assets in stocks in 2000.

Several more incentives arise from the setting. By some non-innocent twist of reasoning, actuaries and consultants often calculate the capitalized value of the promised benefits by discounting them at a rate equal to the estimated expected rate of return on the fund's chosen assets. FASB requires the reporting of the assumed rate of return used in all present value computations, where actuaries generally assume that the risk free interest rate is three or four percent and then add a risk premium to reflect the market risk of the plan investments. Variations in these estimates may result in significant changes in the present value of pension liabilities. Raising the discount rate may be of interest to managers, since net income and potentially linked compensations increase. Investing in equities with a higher expected return is evidently a way for the sponsors to reduce the assessed value of the pension liabilities and, as a consequence, the expected contribution they will be required to make, while letting the employees bear most of the risks of doing that. In current circumstances, both management and shareholders are encouraged to put scheme members at risk by investing in equities.

Unfunded liabilities may be interpreted as a way of issuing non-marketable equity (to the pension fund) to meet specific interests of the companies. The incentive for companies to behave in this way is made worse by executive stock options. The lower assessed value of pension liabilities may induce the stock market to overvalue the equity of the firm. Shareholders and managers holding stock options are the prime beneficiaries of this farce. Moral hazard problems may even arise due to political elements. In the UK, when the stock market was doing well, the Government explicitly authorized corporations to suspend their contributions to pension plans.

In practice, governments are either implicitly or explicitly accepting responsibility for pension deficits. Obviously the belief that the government will bail out scheme members encourages underfunding and miss-matched investment portfolios. All these incentives are to underfund. Paradoxically, tax treatment would induce an economic reason to fully fund pension plans through a debt issue, since the contribution itself and the interest payment on the debt is tax deductible.

In economic reality, only the risk free rate is appropriate to discount pension liabilities in order to obtain the contractual value of the claim, as long as the beneficiaries are not subjected to investment risk. A traded claim on the other hand, just as a corporate bond, would reflect the default risk of the respective plan sponsor, thus incorporating a discount compared to the risk-free contractual present value.

Trading Claims to Create an Appropriate Benchmark

As pointed out, the shortfall in pension assets has occurred in part because of the way the assets of the plans have been managed. They have been managed against a stock-market benchmark, like the assets of any old fund, without sufficient regard to the liabilities of the plan. The reason for this, besides the misaligned incentives, is that overseers needed some yardstick against which to evaluate the quality of pension fund management. Since liabilities are long term and stocks are widely viewed as the ideal long-term investment, it was felt that pension funds should be roughly equity funds and, as such, could be compared in their performance to an equity benchmark. Unfortunately, the recent past has shown that the stock market can drop in value drastically while the outstanding liabilities have, actuarially speaking, remained unchanged in value, causing the shortfall.

What is needed, therefore, is a benchmark that captures the value of the liabilities on a daily basis and against which the performance of pension fund managers could be measured. That would provide them with a strong incentive to manage assets in such a way that they would not become under-funded again. To be meaningful, however, such a benchmark can only be constructed from actual prices of trades. A prerequisite of benchmark construction is the organization of a market for pension liabilities. The market would make it possible to mark-to-market pension liabilities and, in so doing, induce fund managers to manage assets properly. The trading of these securities would also vastly improve transparency at the level of the individual corporation and the individual pension plan as a market value for the pension liabilities could then be calculated every day. One could do away with the yearly, mandatory and shaky assessment made by actuaries. Undoubtedly, pensioners will at the same time realize that the market value of their individual claim, reflecting default risk and underfunding, is much lower than the value corresponding to the promised payments.

Assuming that an active secondary market for collateralized pension claims obligation securities develops, it should not be too difficult to design a benchmark, which would simply be a weighted average, or a collection of specialized weighted averages of pension claim securities prices. Because of the necessary standardization, the value of the benchmark would not be exactly correlated with the market value of the liabilities of a particular pension plan. Managing assets against a pension liability benchmark would still leave a residual or "basis" risk. But, the improvement in incentives would be enormous over a pure stock market benchmark. To price pension liabilities, it would be sufficient to look up the prices of traded securities.

Current Valuation...

The company's liability with respect to defined benefit plans is captured in the so-called projected benefit obligation (PBO), which is the present value of all future pension payments based on expected salary growth and assuming a going-concern of the company. The rate at which future pension obligations are discounted plays a critical role in the present value calculation. Treynor (1977) argues that only the risk free rate is appropriate, as long as the beneficiaries are not subjected to investment risk, to obtain the contractual value of the claim. As he points out, there is no justification for an actuarial practice of discounting pension liabilities at a rate which is related to the historical or expected rate of return on pension assets. Even if disclosure of the discount rate to assess pension liabilities is required by FASB, the company has some discretion when defining the rate. Figure compares applied discount rates with Moody's Aaa corporate bond yields, which are considered a fair surrogate for a risk-free rate. It shows that more than 95% of all firms under consideration applied a discount rate which was considerably above risk-free.

McGill (1979) provides an example where a change of 1% in future rate expectations alters the pension liability by 25%. According to Willinger (1985), a valuation model based on risk-neutral option valuation should reduce the possibility for manipulation in the discounting process, since a risk less discount rate with a narrow range of surrogates is applied.

Required accounting disclosures deviate in several aspects from the economic reality, resulting often in significant over- or underfunding. The application of the expected rather than actual returns from pension assets aims for a smoothing effect, avoiding high volatility in net income. According to FASB, this is justified because the expected return is a long-term measure and is therefore consistent with the long-term nature of plan assets, and because the actual return is beyond the control of the company. Gains and losses of plan *assets* result therefore from differences between expected and actual return. Gains and losses of the plan *liability* depend on changes of assumptions such as the discount rate, salary growth or life expectancy. The net amount of the two differences is deferred

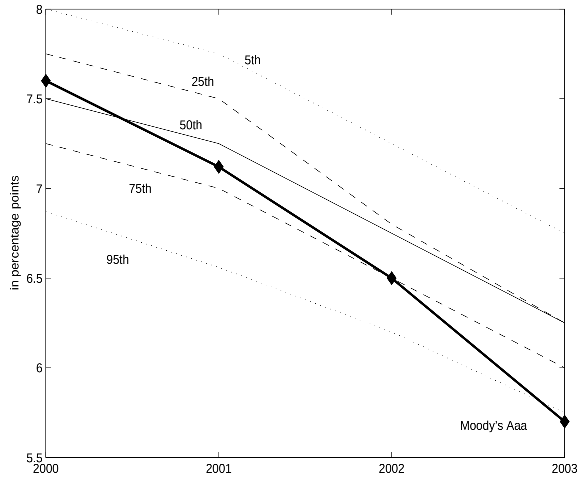

Figure 1: FAS discount rates by percentile compared to Moody's Aaa corporate bond yields. Source: Wilshire 2004 Corporate Funding Survey on Pensions

and amortized over the average remaining service life of the employees, i.e. a quite long time horizon, which is again an assumption made by the plan sponsor.

...and Investment Practices

Basically, defined benefit plans face market risk in two aspects. First, there is the risk that plan assets will underperform liabilities in the long run, commonly called surplus risk. Second, there is the risk that assets and liabilities differ in a given period, referred to as tracking error risk. The ultimate goal of a pension plan must be to have pension assets generate returns sufficient to cover pension liabilities. Therefore, managing funds against liabilities requires immunization. Pension liabilities have some similar characteristics as long-term fixed income investments, thus duration matching is usually applied. The applied discount rate is critical to the computation of duration, thus affecting directly the immunization mechanisms.

In particular, contingent immunization is a commonly used practice. Funds are managed actively as long as the rate of return exceeds a pre-specified safety net return, but once that level is reached, the immunization mode is triggered to lock-in the minimum required return.

It is often argued that long-term fixed income securities, which would provide a high correlation with pension liabilities and thus minimize the risk of a shortfall, may not exist in a sufficient quantity. Interestingly, when the U.S. Pension Benefit Guaranty Corporation was ordered to assume responsibility for the large pension plans operated by United Airlines, long-term bond prices rose promptly. The press interpreted this market reaction as a bet of investors believing that the government agency will, as a result of the event, increasingly focus on immunization and thus switch funds from equities to liability-matching bonds. The further development of derivative markets should help to increase liquidity and correspondingly supply of long-term fixed income instruments.

In order to decrease volatility in fund surplus and in the firm's earnings, investment managers usually measure risk exposure by the correlation between the firm's operating characteristics and pension asset returns, where a lower correlation allows a higher risk tolerance. Generally, the investment policy is meant to be highly correlated with pension liabilities, but uncorrelated with the firm's core operations. This diversification effect is targeted to be reflected in a lower default probability.

Pension plans that offer the option of either retiring early or receiving lump sum payments decrease the time horizon of the liability and increase the liquidity requirement of the plan, which in turn decreases the ability to assume risk. Also, the age of the workforce and the ratio of active to retired lives are important characteristics influencing the ability to take risk. Further, liquidity requirements are higher when the workforce is older, resulting generally in a focus on income assets. The time horizon is usually long on a going concern basis, but very short for a terminating plan.

Credit Risk

To some extent, the longevity and salary growth risks can be likened to other risks of specific collateralized obligations, such as the prepayment risk of a CMO. While these collateral specific risks require different hedging or tranching techniques, the credit aspect of collateralized obligations is quite common.

Just as loans or mortgages are pooled in traditional CDOs and CMOs, pension claims could be pooled in a CPCO. To demonstrate its mechanism, we use a simple and commonly applied model which provides the basic insights and clarifies the role of correlation, funding level and probability of default with regard to different tranches of a CPCO. The large portfolio approximation model was motivated by the model of Vasicek (1987) and extended by Lucas, Klaassen, Spreij and Straetmans (2001) and by O'Kane and Schloegl (2001), which provide a formula to price specific tranches of any CDO within the large homogeneous portfolio (LHP) context. It allows a good approximation for large homogeneous pools of pension claims, where average default probabilities, recovery rates and correlations can be applied, thus providing the required tractability for our context. According to Lucas et al, 300 exposures provide a good approximation for relatively homogeneous portfolios, while 800 exposures are required for relatively heterogeneous portfolios, making the model a viable alternative to standard Monte-Carlo techniques. While the LHP approach facilitates the illustration of the CPCO mechanism, applied simulation techniques should be in compliance with the characteristics of the specific pool of claims under consideration. Since default correlation is not directly measurable, equity return correlation are usually taken as a proxy. In order to model default risk, we use a one-factor single period model under the risk neutral measure that defines the asset return of a firm i as

$$A_i = \beta_i \alpha + \sqrt{1-\beta_i^2} Z_i \tag{1}$$

where β measures the default correlation of the firm with a common market factor α, i.e. the factor loading of A_i. Z_i is a i.i.d. standard Brownian motion. It is assumed that default occurs if the asset return falls below a threshold factor C_i. Default occurs only if the asset return is below the threshold level at the end of the period, i.e. if it is below that level before the end of the period but recovers thereafter, the firm survives. If desired, the setup can be calibrated to reflect default probabilities over the time horizon under consideration. The expected loss on a claim issued by firm i is thus

$$E[L(A_i, RV_i)] = N(\frac{C_i - \beta_i \alpha}{\sqrt{1-\beta_i^2}})(1 - RV_i), \tag{2}$$

where $N(.)$ is the cumulative normal distribution and RV_i is the recovery value of firm i's pension plan.

Assuming that, conditional on α, asset returns are independent and the portfolio is homogeneous, i.e. β and C are identical for all assets, the fraction of the portfolio consisting of pension claims from a large number of firms which defaults for a given α is

$$\theta = N(\frac{C - \beta\alpha}{\sqrt{1-\beta^2}})$$

and the loss distribution is

$$P[L \leq \theta] = N(\frac{\sqrt{1-\beta^2} N^{-1}(\theta) - C}{\beta})$$

.

This portfolio distribution allows us to derive the loss distributions of individual tranches, which are defined by the starting and ending percentage points of portfolio loss absorption, called attachment and detachment points. The percentage loss of a tranche with an attachment point K_1 and detachment point K_2 as a fraction of the tranche notional is given by

$$L(K_1, K_2) = \frac{max(L - K_1, 0) - max(L - K_2, 0)}{K_2 - K_1}. \tag{3}$$

and the expected loss of the tranche is

$$E[L(K_1, K_2)] = \frac{N_2(-N^{-1}(K_1), C, \rho) - N_2(-N^{-1}(K_2), C, \rho)}{K_2 - K_1}, \tag{4}$$

where N_2 is the bivariate normal distribution with a correlation coefficient $\rho = -\sqrt{1-\beta^2}$. The LHP approximation uses a percentage loss of the portfolio, thus

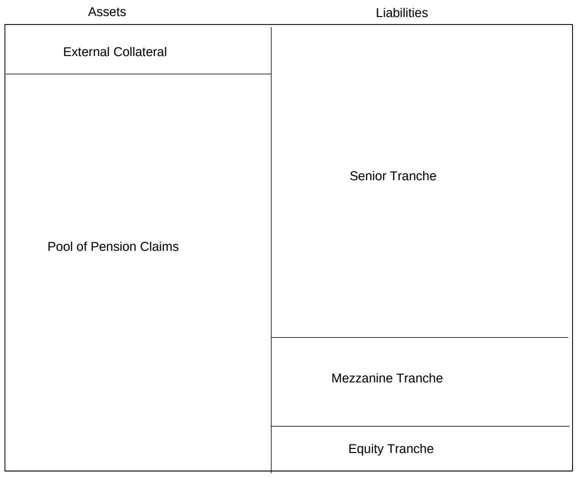

Figure 2: The balance sheet of the intermediary is extended by external collateral bought with the proceeds from the equity tranche sale, feeding the beneficiaries' excess demand for e.g. the senior tranche. The proportions in the figure reflects market values rather than actuarial values.

we need to adjust for recovery values of pension plans RV, i.e. their funding levels. Assuming an average recovery rate within the pool of pension claims, we calibrate equation (4) accordingly.

Risk-Affinity, External Capital and the Hedging of New Risk Dimensions

In a CPCO, risk-averse beneficiaries typically want to take a short correlation position, i.e. a senior or even a mezzanine tranche. The long correlation stake, i.e. the equity tranche with leveraged credit risk, is to be sold to third-party investors such as hedge funds, which are seeking specifically credit exposure. The proceeds from the equity tranche sale are reinvested in riskless collateral, matching the modified duration of the sold equity tranche and filling the "equity tranche gap" of the CPCO (see figure 2). By passing on a tranche of collateralized pension claims, the intermediary is newly exposed to the risk dimensions involved in pension claims but not in substituting collateral. In particular, these are the dimensions of longevity, inflation, and salary growth. The corresponding sensitivities are provided in Appendix B, and are to be treated just as any greeks of derivative securities. The intermediary must synthetically hedge against these risk dimensions. The nominal amount under consideration is the value of the substituting collateral, on which an overlay on the dimensions of longevity, structural salary growth and inflation must be constructed, assuming duration is already matched by the characteristics of the collateral itself. Inflation swaps are readily available in the U.S. and in Europe and serve well as an instrument to hedge against inflation risk. Structural salary growth is more difficult to hedge, economic derivatives would provide an appropriate hedge but haven't fully emerged yet. Finally, longevity is also a source of systematic risk which needs to be hedged. The often discussed issuance of longevity bonds, which are directly linked to the factor, would serve greatly in providing hedging instruments. A few similar mortality-linked securities have already been launched in the recent past. As an endogenous hedge for the longevity factor, the CPCO intermediary could offer incentives to beneficiaries to make them accept lump sum payments upon retirement, which results in the desired effect of reducing the exposure to longevity.

Pricing Pools of Pension Claims

In contrast to traditional obligations, defined benefit pension liabilities face two additional risk dimensions, longevity and salary growth risk. In order to price pools of pension claims and measure their sensitivites, we propose a simplified model which assumes that economy wide pension plans are stable, i.e. that non-vested exits from and entries into plans offset each other, and that plans are ongoing to infinite future. The model aims to provide an approximate value of promised payments on a pool of claims using only the average age of active and retired employees, the average salary at retirement and the average final salary of retirees, in conjunction with the term structure of life expectancy. Even more practical, estimating sensitivities based on this simplified model becomes useful when hedging the risk dimensions of the CPCO. For a detailed approach of valuing mortality risk for life insurances and pensions involving both stochastic interest and mortality rates, see Cairns, Blake and Dowd (2004).

In contrast to retired employees, therefore, as long as an employee is not retired, his/her future pension payments depend on salary growth. Today's value of promised payments on a pension claim of an active worker j shall be defined as

$$\begin{aligned} C_j^A(t_j, T_j, S_j^A, g_j) &= \sum_{i=R}^{T_j} k S_j^A e^{g_j(R-t_j)} e^{-r(i-t_j)}, \qquad \forall\ T_j \geq R \\ &= k S_j^A e^{g_j(R-t_j)} \frac{e^{-r(R-t_j-1)} - e^{-r(T_j-t_j)}}{e^r - 1}, \quad \forall\ T_j \geq R \end{aligned} \tag{5}$$

where S_j^A is the current salary of the active worker, g_j is the expected annual growth rate of his/her salary, r is risk free rate, R is the common age of retirement and T_j is the expected age of death which is directly dependent on the employee's current age t_j. k is a constant that determines the periodic pension payment, which is made at the beginning of the period. For the sake of simplicity, we assume that pension payments are made annually rather than monthly, not impacting the fundamental outcome of the analysis. Equation (5) is based on the assumption that the company has no obligation to protect pension beneficiaries against inflation after retirement. If it turns out that the realized $T_j < R$, C_j^A is assumed to be zero. The claim of a retired, i.e. passive employee is not exposed to salary growth anymore. The value of its promised payments is accordingly

$$\begin{aligned} C_j^P(t_j, T_j, S_j^P) &= \sum_{i=t_j+1}^{T_j} k S_j^P e^{-r(i-t_j)} \\ &= k S_j^P \frac{1 - e^{-r(T_j - t_j)}}{e^r - 1} \end{aligned} \tag{6}$$

where S_j^P is the final salary which the retired employee has achieved in the past.

On an aggregate basis, assuming no correlation between the variables, a pool of n active pension claims and m passive pension claims can be written as

$$\begin{aligned} PoC = &\sum_{j=1}^{n} k S_j^A e^{g_j(R-t_j)} \frac{e^{-r(R-t_j-1)} - e^{-r(T_j-t_j)}}{e^r - 1} \\ &+ \sum_{j=1}^{m} k_j S_j^P \frac{1 - e^{-r(T_j-t_j)}}{e^r - 1}, \qquad \forall\, T_j \geq R \end{aligned} \tag{7}$$

We further assume it is true for a large pool that

$$\sum_{j=1}^{n} S_j^A e^{g_j(R-t_j)} \approx n S^* e^{\pi(R-t^A)} \tag{8}$$

where S^* is the average salary of employees retiring in the current year, π is the expected inflation rate and t^A is the average age of active employees participating in the pool. The component of an individual's salary growth because of seniority and the related increase in productivity is addressed by incorporating salaries at the retirement age, while the purchasing power preserving component is reflected in the inflation rate. Thus, a structural change in the economy-wide salary level is reflected in a change in S^*. Inflationary expectations are commonly estimated at roughly three per cent, but may differ from historical ones. Figure 3 shows the development of the Employment Cost Index (ECI) and the Consumer Price Index (CPI) of the U.S.. The ECI measures the changes in wages, salaries and additional employee benefits. The CPI represents changes in prices of all goods and services purchased for consumption by urban households. The average annual increase in the CPI from June 1981 to the end of 2004 was 3.10% while the inflation-adjusted ECI, i.e. real salary, rose on average by 0.85% p.a. over the same term.

Figure 4 shows the distribution of death at a given age of 40 and at retirement, i.e. at 65. For example, an age of 40 implies a probability of 18.96% of death before retirement, in which case no obligation for the firm would arise. The probability of dying early is incorporated in life expectancy based on the actual age, so the value of a pool of claims can be approximated by

$$\begin{aligned} PoC = nkS^{*}e^{\pi(R-t^{A})}\frac{e^{-r(R-t^{A}-1)}-e^{-r(LE^{A}-t^{A})}}{e^{r}-1} \\ + mk\bar{S}^{P}\frac{1-e^{-r(LE^{P}-t^{P})}}{e^{r}-1} \end{aligned} \tag{9}$$

where LE^A and LE^P is the average life expectancy of all active respectively passive employees, which we obtain using the average of employees' ages t^A and t^P and the term structure of life expectancy, also depicted in Figure 4. $\bar{S}^P$ denotes the average final salary of the retired workers in the pool. The quality of our approximations depends on the joint distributions of the variables S, t and T.

Constructing sub-pools would allow to improve the approximations while maintaining a high level of standardization. Sub-pools should be constructed along the characteristics of life expectancy and expected salary growth, e.g. by forming groups by age and industry. They would also facilitate trading between intermediaries and allow to construct a reasonable benchmark for pension plans. Even if the default correlation within such a sub-pool is higher than desired, due to the categorization by industry, an intermediary can still combine the traded sub-pools in a way to achieve optimal credit diversification. For example, two intermediaries might want to trade the sub-pool "claims of 30 to 40 years aged employees, telecommunication industry". This sub-pool would be a narrow surrogate for the corresponding estimated life expectancy and salary growth, so that a notional based on promised payments can be calculated. The market value of this notional will of course reflect the credit characteristics of the relevant company names, just as in any CDO.

The impact of any change in life expectancy or salary growth on a large pool of pension claims can be measured by the corresponding sensitivities based on Equation (9). For example, unanticipated changes in life expectancy can arise from events such as the outbreak of a mass disease, or the cure against a common cause of death, such as cancer. In a manner similar to the commonly used duration concept, we assume a parallel shift in the term structure of life expectancy to obtain a sensitivity measure.

Salary growth can be decomposed into inflation salary growth and structural salary growth. While inflation salary growth can be hedged using inflation derivatives, structural salary growth imposes a risk that is difficult to hedge, but its idiosyncratic component should be absorbed by diversifying a pool's pension claims across industries. A structural change in salary growth is captured in a change of S^*.

We ignore the Fisher-effect, i.e. a positive correlation between inflation

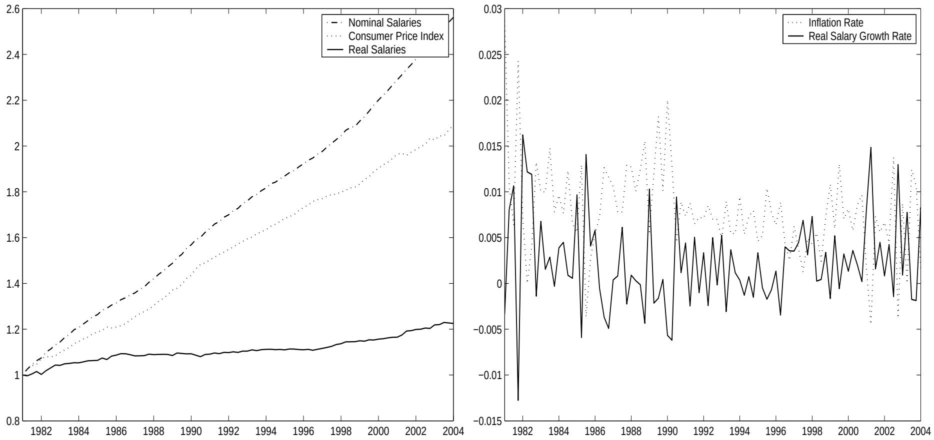

Figure 3: Left: The development of the CPI, the ECI and the inflation-adjusted ECI from 1981 to 2004. Right: quarterly changes of the CPI and the inflation-adjusted ECI. (Source: Bloomberg)

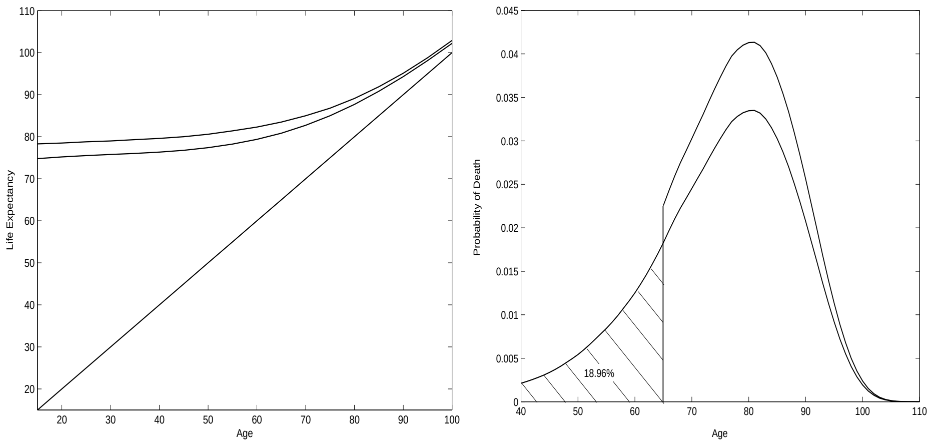

Figure 4: Left: The term structure of life expectancy and its shift from 1984 to 2003. Right: A typical distribution of death at the age of retirement and at the age of 40. (Based on UP-1984 Mortality Table, IRS Cumulative Bulletin 89-25 and National Vital Statistics Report, Vol.53, No. 15, February 28, 2005)

and nominal interest rates, since interest rate movements in the short term do not necessarily reflect a change in expected inflation, but clearly impact the valuation of the pool of claims. We therefore treat the sensitivity to interest rates separately using the traditional duration concept. The equations for all mentioned sensitivities are provided in Appendix B.

In sum, there are several risk dimensions involved in a pool of pension claim. On one hand, interest rate and inflation risks can be hedged with readily available instruments fairly well. On the other hand, structural salary growth and longevity risks are more difficult to hedge, and a considerable mismatch could result. New instruments such as longevity bonds and economic derivatives would greatly improve the handling of these risk dimensions. On top of that, there is always model risk, since the model makes several assumptions such as a fixed retirement age as well as zero correlation between risk factors and provides only approximative present values of promised payments.

CPCO: Elimination of Idiosyncratic Risk and Reallocation of Systematic Risk

Trading defaultable assets is not a far-fetched idea. Pooling and tranching risks of liabilities, typically in the form of a collateralized debt obligation (CDO), have become increasingly popular in recent years. Repackaging traded pension claims analogously is a reasonable approach to deal with the risks involved. As most collateralized obligations, a CPCO has two basic objectives with regard to risk. First, idiosyncratic risk is to be diversified away, as the number of individual claims increases. That is, pooling losses increases the probability of small losses but drastically reduce the chances of a major reduction in any pensioner's retirement income.

Second, tranching allows reallocation of systematic risk, shifting expected losses and returns in accordance with different risk/return profiles that may be desired by beneficiaries. The assets of the CPCO would be a pool of pension claims handed over by beneficiaries. For a number of reasons, a beneficiary may have reconciled himself/herself with the idea that he will never collect the full face value of the claim, and may be uncomfortable with the specific risk of the plan sponsor. In exchange for the personal claim he/she trades in, the participant gets a claim on a CPCO tranche, which he/she selects according to his risk affinity and in the context of his/her overall wealth. Moreover, should his risk preferences change during his lifetime, he could just exchange his claim against one of another tranche, which better reflects his updated risk/return-profile. It must be recognized that the transfer of pension claims will raise thorny legal issues since the claim to pension benefits is nominative and tied to the survival of one particular individual. We assume that legal issues can be resolved. Otherwise, it may be necessary to reformulate the idea as an insurance product instead of a security.

Initially, the value of the claim on the tranche equals the market value of his pension claim, which is estimated as a series of payments in conjunction with the expected loss on his claim, i.e. the default probability of his employer implied by other traded liabilities such as corporate bonds in combination with the funding level of the corresponding pension plan. In effect, when exchanging an individual claim against a tranche of a CPCO, the present value of the promised payments is multiplied by the ratio of 1 minus the expected loss on the individual claim to 1 minus the expected loss on the tranche

$$\xi = (1 - E[L(A_i, RV_i)])/(1 - E[L(K_1, K_2)]) \tag{10}$$

and ξk replaces k when defining a beneficiary's pay as percentage of his final salary.

As mentioned, the CPCO modifies a beneficiary's risk in two ways. While the idiosyncratic risk is diversified away, insurance against systematic risk can be bought or sold. Should the beneficiary choose a tranche with the same expected loss as his existing claim, ξ would equal one and a zero insurance premium would be paid. Beneficiaries exchanging their claims for a part of the senior tranche buy in fact insurance against losses, assuming their claim has average systematic risk. The analogy of CPCO tranches to options on portfolio losses provides the corresponding intuition. The premium of such an insurance, as percentage of the present value of promised payments, equals $1-\xi$ and can thus be negative in case ξ is greater than one. Thus, depending on the selection of the tranche and the systematic risk of the individual claim, a beneficiary can buy as well as sell insurance, according to his/her preferences. The benefits of diversification apply regardless of the insurance discussion.

With such a structure, risks of pension claims could be optimally distributed in the population of beneficiaries, and investors generally. Although a tranche of any arbitrary risk level ξ could be offered to beneficiaries, a limited number of risk categories would be appropriate. This way, participants have simply to choose the desired category, trading off the level of promised payments against systematic risk. A simple structure will reduce the need to educate potential participants about the mechanism of a CPCO and should ease adoption. The only choice faced upon participation is the selection of a risk class, i.e. the respective tranche.

On average, we expect more buyers than seller of insurance in the given cohort of risk-averse beneficiaries, thus the need to sell the most risky so-called equity tranche to third-party investors such as hedge funds. The presence of third-party investors provides the (not unlimited) guarantee to owners of safer tranches. They are essential to the manufacturing of the riskless long-term assets that are in insufficient supply in today's financial markets.

The implied expected loss on mezzanine and equity tranches seems to be high at first sight. However, credit spreads are typically larger than the level implied by historical default rates. This spread premium, often overcompensating the involved systematic risk, can be levered in a mezzanine tranche and allows beneficiaries to take advantage of it. Typically, beneficiaries with relatively high savings are less risk averse with regard for their pension income and might choose this option. Equity tranche investors, providing risk capital, are usually also attracted by this fact, as can be observed in the CDO market.

Generally, the tranche spread and the associated expected loss depend on multiple factors, such as attachment and detachment points, tranche width, credit quality of collateral, funding level of pension plans (i.e. recovery rates) and default correlation of claims in the portfolio. Figure 5 shows the impact of correlation and recovery rates.

Adoption of CPCOs and the Government's Role

Given a posted market price for pension claims, companies would have an incentive to fully-fund their plans. Since underfunding can be assumed to be massive for many large corporations, making up for the gap will be a straining task. Thus, companies have an incentive to deny participation in a CPCO, avoiding increased transparency and the associated necessary contributions. Only if public or governmental pressure forces numerous companies to participate, could the cure to the pension system take effect. Government should be interested in establishing a pension claim market, since benefits to social welfare as well as those to the government itself are considerable.

The U.S. Employee Retirement Income Security Act (ERISA) of 1974 has created a Federal agency called the Pension Benefit Guaranty Corporation (PBGC) to [encourage the growth of defined benefit pension plans, provide timely and uninterrupted payment of pension benefits, and keep pension insurance premiums at a minimum]. Governmental agencies such as PBGC are charged with compensating the beneficiaries if a plan ends without sufficient money to pay all benefits, but is not compensated adequately by the insured companies. In effect, the pension risk was transferred from the beneficiaries to PBCG and clearly missed the original intention at least partly.

The role of government guarantees changed in type with the evolution of pension systems. Privatization reforms often led to a conversion into defined contribution plans, which expose beneficiaries to risks not previously faced in a defined benefit plan. They are forced to bear the risk of inappropriate asset allocation, and the risk of improper tactical allocation, which is implemented by an asset manager and difficult to monitor. That is another manifestation of moral hazard: not only have corporations, governments and financial institutions failed to provide households with proper pension protection, they now wish them to bear the responsibility of investment decisions that would reconstruct for them a proper level of retirement income. As pointed out in Mitchell (2004), numerous examples of the foolish investment elections made by employees operating under defined contribution plans suggest that employees do not have the expertise necessary to choose investments in a way that will provide them with the retirement income they desire.

Defined contributions plans represent an inferior contract design, in which employees are left to their own woefully insufficient devices, with the consequence that some suffer devastating losses and unexpectedly have to extend by

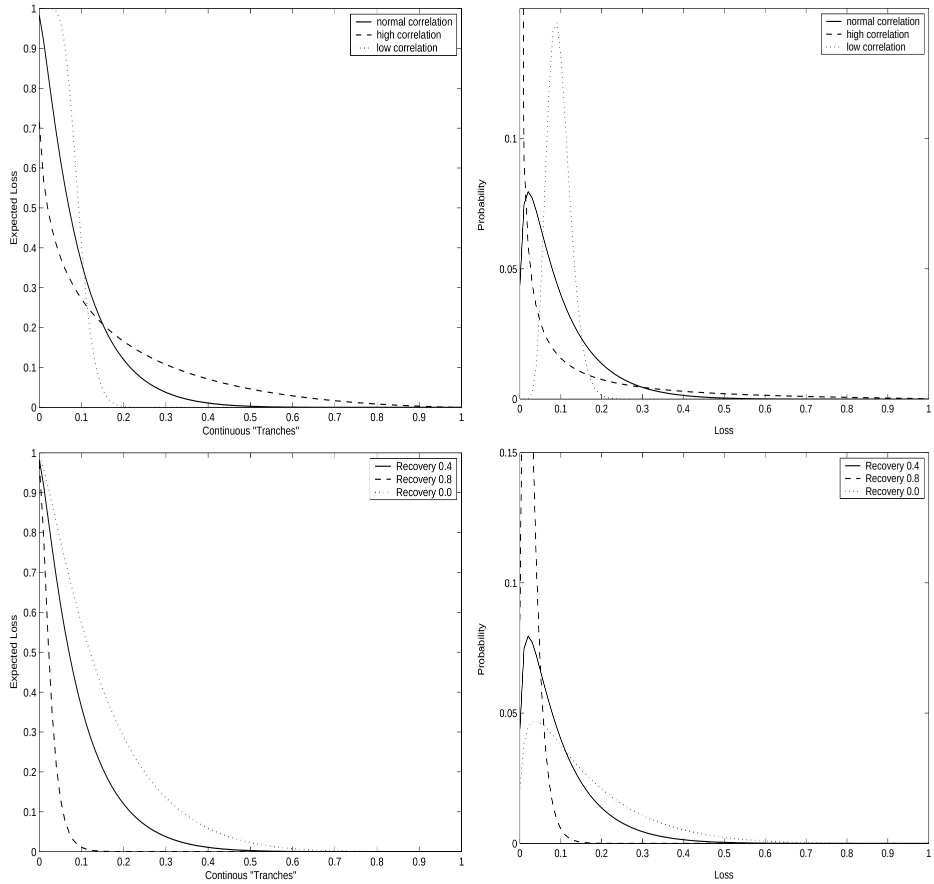

Figure 5: Left graphs: The behavior of a CPCO sliced in continuous tranches when correlation or the recovery rate is changed. Right: Loss distributions for CPCO with different correlation and recovery rate levels.

a decade their working life. For some, this is a tragedy. Many experience this tragedy today in the United States. In order to convince employees to convert their plans, governments had to provide guarantees that reduce an individual's investment risk, such as a fixed minimum rate or a minimum rate relative to the performance of other pension funds. In general, government guarantees cause a large burden on the taxpayer, in addition to potential agency problems. Moreover, mostly due to aging populations, governments consider shifting from tax-funded pay-as-you-go systems to funded ones. This change would have the potential to lower the tax burden for future generations, and would underline the importance of the alignment of incentives involved in funded systems. Having markets and values for pension claims, life expectancy as well as expected salary growth will clearly help to achieve this alignment, and financial vehicles such as a CPCO would be able to allocate risks and returns appropriately. Opening these markets is also likely to considerably reduce the currently high level of administrative costs.

An Illustrative Example

In order to illustrate the mechanism of a CPCO, we consider the following example. Let's assume we have a pool of claims consisting of 500 active and 300 retired workers. The average salary of employees retiring in the current year is USD 150,000, and the average final salary that the participating retired employees achieved is USD 120,000. The average age of active workers is 40, and the one of retirees 70, so their average life expectancies according to the term structure of life expectancy, are 79.6 and 85.0 respectively. A pension payment corresponds typically to 80% of the final salary. The expected inflation rate is 3% and the interest rate is 6%. The general retirement age is 65.

The present value of the promised payments on this pool of claims, according to Equation (9), is USD 572.19mn. Observing that the pool, consisting of traded claims, has a market value of, say, USD 517.04mn, we imply an average loss probability of 9.49%. We further observe an average correlation of all claims in the pool of 0.5 and, following the statistics of the U.S. Pension Insurance Data Book, an approximate average funding level of 40% in case of bankruptcy. We calibrate our model accordingly.

Let us consider now an employee, aged 35, with a current salary of USD 80'000 and an expected salary growth rate of 4% p.a. His/her expected terminal salary at 65, i.e. 30 years from now, is therefore USD 265'610 and his/her pension claim has a risk free present value of USD 362'290. Assuming he/she is able to trade this claim for USD 335'000, the market expects a loss probability of 7.53% on his/her claim. Since claims are traded, arbitrageurs make sure that this probability is consistent with the one of other outstanding liabilities of the respective company.

The intermediary running the CPCO offers three tranches, a senior tranche, a mezzanine tranche and an equity tranche. The attachment points are chosen such that the equity tranche absorbs the first 10% loss of the pool, the mezzanine

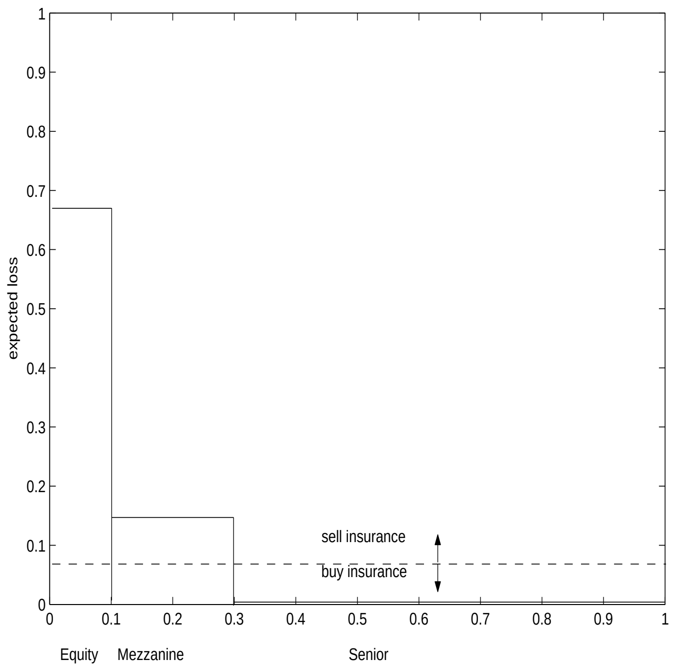

Figure 6: Widths and expected losses of a CPCO's three tranches

tranche the next 20%, and the senior tranche takes the losses exceeding 30%. According to our assumptions above, the senior tranche has an expected loss of 0.24%, the mezzanine tranche one of 13.65%, and the equity tranche one of 67.41%, as shown in Figure 6. Thus, the equity tranche has a value of USD 18.65mn, the mezzanine tranche has one of USD 98.82mn and the senior tranche one of USD 399.57mn. The equity tranche is sold to a third-party and the proceeds are invested in low-risk assets, e.g. with a similar expected loss as the senior tranche. Thus, the low-risk tranche is extended to a value of USD 418.22mn while the mezzanine tranche stays the same.

Our employee, according to his/her risk-averseness, wishes to exchange his/her claim for a piece of the senior tranche, meaning he/she chooses a ξ of 0.9269. By doing this, he/she has not only diversified away the idiosyncratic risk of his/her employer, but has also reduced his systematic risk considerably to his/her desired level. While the first improvement comes at no cost, the second one decreases his payout ratio from $k = 0.8$ to $\xi k = 0.74$. Should the employee have a more aggressive risk/return profile, he/she might select the mezzanine tranche. In this case, he/she would sell insurance, i.e. assume more systematic risk, while increasing his/her payout ratio from $k = 0.8$ to $\xi k = 0.86$.

In order to maintain the exposure to any risk dimension as low as possible, the intermediary must hedge against changes in longevity, inflation and salary growth, using sensitivity measures such as the ones provided in Appendix B. The notional, i.e. the risk-less present value to hedge, is reduced from USD 57.22mn to USD 18.69, reflecting that the majority of beneficiaries selects a ξ below 1. However, the intermediary can adjust the number and width of tranches according to observed demand.

Conclusion

The form of securitization that we are proposing will not die with the growth of defined contribution plans. Even then, a household will be made better off by holding the class of CPCO securities that it wishes to hold than by holding a portfolio of stocks and bonds. In this way, it will be able to tailor the risk it bears to its preferences. The defined benefit pension system, in conjunction with financial engineering, is able to achieve lower agency costs than current systems do, while providing an accurate level of safety for pensioners. Providing insurance to the common man is the *raison d'être* of financial institutions. There is no reason for which they should abandon that role when it comes to pensions.

Appendix A: Types of Pension Plans

There are two major types of pension plans, defined contribution plans and defined benefit plans. In a defined contribution plan, the company periodically deposits a specified amount of funds for each employee, but has no asset or liability related to the pension. The company makes no promise regarding the amount that will actually accumulate over time. The employees fully bear the risk of bad performance and often make their own investment decisions in these plans.

In a defined benefit plan, the company promises to pay a certain amount at or after retirement to each employee. These plans are usually sub-categorized in pay-related and non-pay-related plans, differentiating whether the benefit payment is linked to an employee's salary level. Non-pay-related plans typically accrue a fixed amount for each year of service or any other measure. The pension benefits of pay-related plans are based on future compensation, either on the salary at or near retirement or on the average over the whole career, often also combined with a non-linear relation to the number of years of service.

In contrast to defined contribution plans, defined benefit plans impose additional risk on the company, particularly the risk of salary growth and life expectancy as well as the risk of underfunding when the pension's assets don't meet the expected returns.

Bodie and Merton (1988) discuss the relative merits of defined contribution and defined benefit pension plans. For various countries' pension systems, see Davis (1996) and Turner and Watanabe (1995).

Appendix B: Sensitivities of a Pool of Pension Claims

In order to measure the impact of any change in life expectancy or salary growth, i.e. of the newly involved risk dimensions, on a large pool of pension claims, we derive the corresponding sensitivities based on Equation (9). First, we consider an unanticipated change in the term structure of life expectancy. We assume a parallel shift in the term structure of life expectancy, i.e. a change in LE^A occurs together with an equal change in LE^P.

$$\frac{\partial PoC}{\partial LE} = nkS^* e^{\pi(R-t^A)} \frac{re^{-r(LE^A-t^A)}}{e^r-1} + mk\bar{S}^P \frac{re^{-r(LE^P-t^P)}}{e^r-1} \tag{11}$$

A structural change in salary growth is captured in a change of S^*. The corresponding sensitivity is therefore

$$\frac{\partial PoC}{\partial S^*} = nke^{\pi(R-t^A)} \frac{e^{-r(R-t^A-1)} - e^{-r(LE^A-t^A)}}{e^r-1}. \tag{12}$$

A change in inflation on the other hand impacts the pools as follows

$$\frac{\partial PoC}{\partial \pi} = nkS^*(R-t^A)e^{\pi(R-t^A)} \frac{e^{-r(R-t^A-1)} - e^{-r(LE^A-t^A)}}{e^r-1}. \tag{13}$$

Finally, we obtain the sensitivity to interest rates, i.e. the modified duration as

$$\begin{aligned}\frac{\partial PoC}{\partial r} = &\frac{1}{(e^r-1)^2}(k(e^{r+\pi(R-t^A)}(e^{r(t^A-LE^A)} - e^{r(1-R+t^A)})nS^* \\ &+ m\bar{S}^P e^r(e^{r(t^P-LE^P)} - 1) \\ &+ nS^* e^{\pi(R-t^A)}(e^r-1)((LE^A-t^A)e^{r(t^A-LE^A)} \\ &+ (1-R+t^A)e^{r(1-R+t^A)}) \\ &+ m\bar{S}^P(LE^P-t^P)e^{r(t^P-LE^P)}(e^r-1))).\end{aligned} \tag{14}$$

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