



Managing contribution and capital market risk in a funded public defined benefit plan: Impact of CVaR cost constraints

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ABSTRACT

Using a Monte Carlo framework, we analyze the risks and rewards of moving from an unfunded defined benefit pension system to a funded plan for German civil servants, allowing for alternative strategic contribution and investment patterns. In the process we integrate a Conditional Value at Risk (CVaR) restriction on overall plan costs into the pension manager's objective of controlling contribution rate volatility. After estimating the contribution rate that would fully fund future benefit promises for current and prospective employees, we identify the optimal contribution and investment strategy that minimizes contribution rate volatility while restricting worst-case plan costs. Finally, we analyze the time path of expected and worst-case contribution rates to assess the chances of reduced contribution rates for current and future generations. Our results show that moving toward a funded public pension system can be beneficial for both civil servants and taxpayers.

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1. Introduction

Traditional PAYGO public pension plans confront demographic aging in most developed nations, and some policymakers advocate boosting funding to ease the crunch of paying for the future pension liability. In the case of civil servant pensions, a handful of these have substantial assets including in the Netherlands (ABP, 2006) and the state of California (Mitchell et al., 2001). But more

generally, and in Germany in particular, civil servants are often promised a non-contributory, tax-sponsored defined benefit (DB) pension which is usually not funded. This study evaluates the impact of an alternative approach to public sector pension fund management, by deriving optimal contribution rate and asset allocation patterns in a partially funded scheme for the German federal state of Hesse. We show this approach can be useful in permitting a state to finance its public pensions so as to cut costs for taxpayers and enhance pension security for participants.

Plan sponsors are generally concerned with two types of risk, namely contribution rate and solvency risk (Lee, 1986; Haberman et al., 2000). When managing the funded pension, plan sponsors and beneficiaries wish to insure that plan funds will be sufficient to cover pension liabilities, while ideally smoothing contribution rates over time. To combine both types of risk, traditional studies on managing DB pensions have introduced a quadratic cost

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criterion as the plan manager's objective function (c.f. Haberman and Sung (1994, 2005), Haberman (1997a,b), Ngwira and Gerrard (2007) and Owadally and Haberman (2004)). These risks are typically measured by squared deviations of current contribution rates and funding levels from their expected or notional values.³ Another approach adopts a Conditional Value at Risk (CVaR) criterion as a key risk measure used for plan control: the CVaR of a parameter at the $\alpha\%$ confidence level is defined as the parameter's expectation under the condition that its realization exceeds the Value at Risk (VaR) for that level (Artzner et al., 1997, 1999; Rockafellar and Uryasev, 2002). For instance, Bogentoft et al. (2001) include CVaR constraints on funding levels while seeking to minimize total costs of pension funding. Maurer et al. (2008a,b) directly minimize the Conditional Value at Risk of total pension costs, while Haberman et al. (2003a,b) investigate the trade-off between mean shortfall risk (i.e. CVaR on plan solvency) and excess contribution rate risk.

In this paper, we identify contribution and investment strategies that minimize pension contribution rate risk (as in Haberman et al. (2000)), and we also impose CVaR restrictions on total plan costs appropriate to a public pension scheme.⁴ Focusing on the CVaR of the stochastic present value of plan costs offers an elegant and objective way to compare different intertemporal contribution and investment paths on a common basis. Moreover, this approach allows us to explicitly incorporate decisionmakers' risk budget, by defining the maximum admissible CVaR of plan costs.

We implement our approach in the context of German civil service pension plans. To date, only two German states have started funding a portion of their public pension liability, depositing 20%–40% of covered payroll to the active civil servants' pension fund; these investments have been mainly restricted to government bonds. To illustrate the power of our model, we examine the Hessian public pension plan which we argue is rather representative of the public sector environment in Germany. We show that controlling only on costs requires a high regular contribution rate of about 40% of covered payroll. Conversely, focusing only on contribution rate volatility yields low regular contribution rates and low-risk asset allocations, but taxpayers are exposed to substantial risk of extraordinary but predictable transfers to cover shortfalls. Combining both approaches can produce moderate contribution rates accompanied by a substantial equity portfolio which generates acceptable contribution rate volatility while keeping total pension costs under control.

In what follows, we briefly describe the public pension on which we focus, and we derive the value of plan liabilities and payroll-related contribution rates needed to finance them. Section 3 outlines the plan manager's objective function and the model underlying the asset/liability management process. Results of our stochastic simulation study are detailed in Section 4. Section 5 concludes.

2. Valuing public pension liabilities in a non-stochastic framework: The German civil servant plan

German civil servants have traditionally been promised a non-contributory, tax-sponsored, unfunded, and relatively generous

DB-type annuity that depends on retirement age, years in civil service, and final salary.⁵ In exchange for this plan, civil servants do not participate in the national social security system nor are they covered by supplementary occupational pensions (Heubeck and Rürup, 2000). Over time, civil servant pensions have become less generous: the retirement age, which had been 65, is being raised to 67, and pension accruals have been reduced to approximately 1.79% of final salary per service year. This will generate a maximum replacement rate of 71.75% after 40 years of service (versus 75% under the old rules).

2.1. Civil service employee dataset

We base our assessment of the public plan by focusing on civil servants employed by the German federal state of Hesse. This population of civil servants is rather representative of the approximately 1.5 million active (about 4.5% of the workforce) and 900,000 retired civil servants in Germany as a whole.⁶ The dataset provided by the Hessian Statistical Office includes anonymized files on active civil servants in 2004 in Hesse reporting their age, sex, marital status, line of service, and salary.⁷ There are 104,919 active civil servants in the database: the average age is 44.7 years, earning an average salary of € 39,000, and 45% female. Payroll amounted to an annual € 4.26 billion or 33% of Hesse's annual state tax revenues in that year.

2.2. Population dynamics and economic assumptions

This analysis of a transition toward a funded pension incorporates both current employees as well as those to be hired in the future into the calculations. (Unfunded past service liabilities are assumed to be covered from other revenue sources, as in Maurer et al. (2008a,b)). Projecting the civil service population requires forecasting the evolution of age and salary for existing employees, as well as making assumptions about new hires. Since practically speaking, employee turnover for reasons other than retirement is insignificant, we assume that all workers remain active until age 67 and reach retirement with certainty.⁸ Vacant positions are assumed to be filled with new recruits with a 50% chance of being male or female. Each new worker's entry age is set to the empirical average age of new hires, accounting for average time spent in position-related education or service credited as prior creditable years. New workers receive the age-related remuneration for their positions and marital status is that of the previous position holder. Retired civil servants are represented by the expected cash flows of the indexed life annuities they receive according to the civil service pension benefit formula. (For married retirees we calculate indexed joint-and-survivor annuities, assuming that both partners are of the same age and opposite sex.)

To value the civil servant pension liability profiles, we use mortality tables specific to the Hessian civil service derived by Maurer et al. (2008a). Future mortality improvements are incorporated using an exponential trend function suggested by

⁵ For a more detailed discussion of the German civil servant pension system and the dataset employed in this study, see Maurer et al. (2008a,b).

⁶ These numbers include only federal and state civil servants, but not the approximately 200,000 active and 500,000 retired civil servants who worked for former state-owned (now privatized) enterprises such as the German national railway and federal mail (Bundesministerium des Innern, 2005).

⁷ Information on a handful of top-level civil servants, judges, and state attorneys is omitted to preserve anonymity.

⁸ Provisions for early retirement and disability benefits, as well as dependents' benefits due to death in service, must therefore be conducted separately from this analysis.

³ Other plan manager objectives could include expected utility from dividends paid by the pension plan or from possible terminal surplus values (c.f. Hainaut and Devolder (2007) and Detemple and Rindisbacher (2008)).

⁴ In accordance with Feldstein and Rangelova (2001) and others, we suggest that the decision to start prefunding an initially unfunded public pension plan requires attention to the cost risks associated with funding and investing in capital markets. Such a strategy may be considered only if these risks can be held to acceptable levels. Accordingly, we incorporate a restriction on the maximum size of plan costs in worst-case scenarios.

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