Defined Benefits Plans vs. Defined Contribution Plans: An Evaluation Framework using Random Returns

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Paper presented at the Annual Conference of
Academy of Financial Services
in Las Vegas, October 2016

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INTRODUCTION

Compensation packages offered by many employers, especially the larger corporations and public sector employers such as government agencies and state universities, have included retirement benefits. These benefits traditionally were in the form of "pensions," which were typically some clearly defined function of the employee's service and salary history. Employer pension plans have undergone a steady, and in some cases, rapid transition from well-defined post-retirement pensions, based on salary and service history, to investment plans to which employers contribute a percentage of the employee salary. The former plans, commonly known as *defined benefits* plans (DB), are usually seen as reliable and steady sources of post-retirement income. The latter plans, usually known as *defined contribution* plans (DC), result in an accumulation based on the investment returns of the plan's assets. The employees bear the investment risk. It is commonly perceived that the outcomes from the DC plans would be more risky and less desirable for the employee than those from a DB plan. Extant research, pioneered by Bodie, Marcus, and Merton (1988) and Poterba, Rauh, Venti, and Wise (2007), show that the trade-off between the two pension plan structures are far less clear-cut than is commonly perceived. Neither structure dominates the other under all circumstances. In spite of the clear lack of overall superiority for the DB plans over DC plans, a general and popular perception is that DB plans are better and more beneficial for the employees.

This paper analyzes a DC plan, which has been tentatively discussed by a state university as an alternative to the current DB plan. The analysis uses a very general framework with different employee service assumptions and random investment returns to generate distributions for DC plan accumulations that can be compared to the present values of the DB plan benefits. The paper also analyzes the implied options available with both structures. Our initial finding confirms the evidence from extant research indicating a lack of dominance for one structure over the other. Employees, in general, should find it beneficial to be offered the choice of both structures and be able to choose one or the other depending on one's expected longevity with the employer and personal risk tolerance. The framework used in the paper can be readily adapted to evaluate different DC and DB plan structures.

LITERATURE REVIEW

Extensive research comparing defined benefit and defined contribution plans have been conducted. It is well documented that certain characteristics and/or circumstances influence individuals' benefits between DB and DC plans. Early works include Bodie, Marcus, and Merton (1988) in which they determined neither plan dominated the other in all circumstances. DB plans were found to have the advantage of "stable replacement rate of final income to workers". However, DC plans were found to be advantageous when inflation uncertainty existed. They suggested that a combination of both plans could possibly be superior.

Older workers and those who plan to not move benefit more from a DB plan, while DC plans are generally more beneficial for younger and more mobile workers (Childs et al ,2002; Shrager, 2009).

Several works have compared the two plans using varying returns from differing portfolios. In 2001, Johnston, Forbes, and Hatem compared hypothetical state university DB and DC plans using a Monte Carlo simulation. They made assumptions for the DC plan using current years worked, beginning salary, growth rate in salary, and salary deduction plus sponsor's matching percentage contribution. Their DB plan used number of years work, final average salary, percentage rate for defined benefit formula, and inflation rate. According to their model, using a DC plan would need to invest with high stock allocations such as, 70/30 and 80/20 in order to exceed the benefits of a DB plan. Their investment alternatives included a diversified portfolio of large capitalization stocks and bonds and a portfolio of long-term investment grade corporate bonds.

A comparison among DB and 401(k) plans conducted by Samwick and Skinner (2004) used data from the Surveys of Consumer Finances from 1983 to 2001. Their study included simulations of earnings and returns on various assets, including company-owned stock, resulting in 401(k)plans having equal or better benefits than DB plans. Although 401(k) benefits were lower in later years, higher returns in other years offset to balance out total returns. In their study, Munnell et al (2006) reported that from 1988-2004, DB plans outperformed 401(k) plans by one percentage point. This differential may be explained by the fact that nearly 50 percent of the 401(k) participants were not diversified in their holdings (almost all

stocks or no stocks) lowering their returns, and higher fees which also offset some returns. Using data from annual faculty censuses of the University of North Carolina system, Clark, Ghent, and McDermed (2006) calculated present value pension benefits of a defined benefit plan and a defined contribution plan, assuming a risk-free world and retirement at 65 after 30 years of employment. Their findings resulted that, due to higher lifetime earnings, men always had greater pension wealth under a defined contribution plan, assuming an allocation of 50% stocks with 6% returns and 50% bonds with 3% returns. However, under the same circumstances, the defined benefit plan would have greater value for women because they have longer life expectancies than men. They concluded that workers preference for which type of plan is based on age, gender, mobility, risk aversion, and other various factors.

Poterba, Rauh, Venti, and Wise (2007) also compared plan outcomes using different investment alternatives. These alternatives included portfolios consisting of: (1) TIPS; (2) long-term government bonds; (3) corporate stock; (4) 50-50 stocks and TIPS; (5) 50-50 mix of stocks and government bonds, (6) lifecycle portfolio of stocks and TIPS, and (7) lifecycle portfolio of stocks and bonds. They used actual retirement plans, earnings, and employment history of 1400 respondents from the Health and Retirement Study (HRS). Similar to Johnston, et.al, they found that "if equity returns follow their historical empirical distribution, an individual in a DC plan who makes substantial equity investments will usually achieve a higher retirement wealth in a DC plan than in a public sector DB plan. If equity returns are 300 basis points lower than their historical empirical distribution, it is possible that

the distribution of outcomes with the DC plan may look less attractive than the DB plan for some risk-averse households" (p. 2077).

Ezra (2007) suggests that the outcomes of DC plans are not as clear as DB plans and that it is not always a low-cost option. DC plans often have higher record keeping costs, investment management fees, and rates to purchase annuities may be higher. Munnell, et. al (2008) also concur that DC plans are more costly for states to administer than DB plans, which are mostly free from regulatory costs. Employee Retirement Income Security Act (ERISA) administrative expenses and Pension Benefit Guaranty Corporation premiums don't apply to public sector plans. Mannino and Cooperman (2009) used data of the Colorado Public Employees Retirement Association (PERA) retirement plans covering employee salary histories and retirement records to estimate the level of deferred compensation in the defined benefits plans for the state employees. They used five different measures to estimate the level of additional benefits above a hypothetical defined contribution plan that received the same contribution. They found that the type of jobs, number of services years, and retirement age to be significant factors in the level of benefits. The main implication of their findings is that a DC plan receiving the same contribution as the contribution to the PERA DB plan, would have to earn market returns of about 8 percent higher than the guaranteed return offered by PERA. It should be mentioned that PERA, like most other DB plans run by state agencies, has significant unfunded pension liability implying a need for continuing subsidies by the state government to keep the plan solvent. It is also worth noting that the pension benefits offered by PERA are very generous at 2.5 percent of estimated

salary for each year of service with a very liberal and fixed annual inflation indexing of 3.5 percent.

Munnell (2014) finds an increasing incidence of the DC plans in public sector as partial or full replacements for the DB plans. This trend, while significant, represents only a small percentage of pension assets now. While the trend was visible before the financial crisis of 2008, there appears to be some change in the approach to pension benefits since the crisis. In some cases, DB plan commitments are being pared by reducing pension benefits or cost of living adjustments. New proposals are also being initiated to partially or fully replace DB plans with DC plans.

Implications of Extant Research Findings

It is difficult to generalize the implications of the extant research on comparison of DB and DC plans as the details of the plans studied vary. Most of the research reviewed here used data relating from actual employee salary history and retirement records to compare current DB plans to hypothetical DC plans. It is clear that the benefits provided by the public sector DB plans are rather generous for the given levels of contributions to the plans. This fact is reflected in the large unfunded liabilities of most public sector plans. In short, a DC plan is unlikely to give the same benefits if the contributions are only at the level of the extant DB plan.

Poterba, et al (2007) suggest that risk of DB plans may be underestimated and there has been no attempt to quantify the same. There are several incidents of benefit cuts in private sector DB plans and even in some public sector plans. It should be noted that the generous pension benefits, which are not supported by employee

contributions, have to come as costs to employers. There have been few attempts at evaluating the cost to employers. Public sector plans are considered safe primarily because of the implied state government guarantee. This guarantee is only as safe as the taxpayers' future willingness to bear the burden. We suggest that DB plan benefits should not be treated as risk-free cash flows.

EVALUATION OF A DC PLAN

The focus of our paper is to evaluate benefits to the employees from a proposed DC plan as a possible replacement to the current DB plan. We attempt to provide a general framework for evaluating similar proposals. The proposal studied in the paper arises from a tentative plan that was discussed in a state university. The current retirement plan is a DB plan providing pension benefits calculated at the rate of 2% of salary for each year of service. The plan is managed by the state teachers' retirement system. The plan uses the so-called rules of 80 or 90. This means that one is eligible for full retirement benefits when ones age plus years of service reach 80 or 90 as the case may be. Rule of 80 apply to employees in service prior to 1992 and rule of 90 apply to those with service starting later. Alternately, one is vested with full pension benefits after 5 years of service and reaches the retirement age, assumed to be 65 years. Employee contributes[1] 7 percent of salary for the first $10,000 (or a maximum of $700). Employer's contribution is set by the state teachers' retirement system at 8.5 percent of salary. The proposed DC plan

[1] The plan requires employee contribution of 7 percent and employer contribution of 8.5 percent. In the case considered here, the university contributes the 7 percent for the employee after the first $10,000.

alternative provides for an employer contribution of 10 percent and no required employee contribution. We assume full vesting after 5 years of service. Employee is free to invest the funds as she chooses.

Methodology

We use a simple framework of analysis that compares estimated present value of benefits from DB plan with accumulated value in the DC plan assets for different service periods. We assume two levels of pension benefits, 20 years and 25 years, and use five-year increments for the service period assumptions to compute the present values of the DB pensions at the age of 65 years. The DC plan contributions are assumed to be invested in a portfolio of stocks and bonds. We use two portfolio compositions: 70 percent stocks, and 80 percent stocks, with the remaining invested in bonds. For the DC plans, we compute the accumulated values of the contributions at the age of 65 using random returns. The table below summarizes the key assumptions used. We use historic S & P 500 and Treasury bonds returns for the period 1929 to 2015.

TABLE 1	
KEY ASSUMTPIONS	
STARTING AGE	30
STARTING SALARY	$50,000
INCREMENT - PERCENTAGE	3.0%
AGE FOR FULL RETIREMENT BENEFITS	65
DC CONTRIBUTION (PERCENT OF SALARY)	10%
INVESTMENTS FOR THE DC PLAN	
PORTFOLIO COMPOSITION - 1	
STOCKS	70.0%
BONDS	30.0%
PORTFOLIO COMPOSITION - 2	
STOCKS	80.0%
BONDS	20.0%
INVESTMENT RETURNS	
STOCKS: MEAN	11.00%
STOCKS: STANDARD DEVIATION	20.0%
BONDS: MEAN	5.2%
BONDS: STANDARD DEVIATION	7.8%

RESULTS

Figure 1 provides a graphic presentation of the results of simulations for the DC plan portfolios and the DB plan benefits. The mean accumulated values for the DC plan are higher than the present value of pension benefits for all service periods.

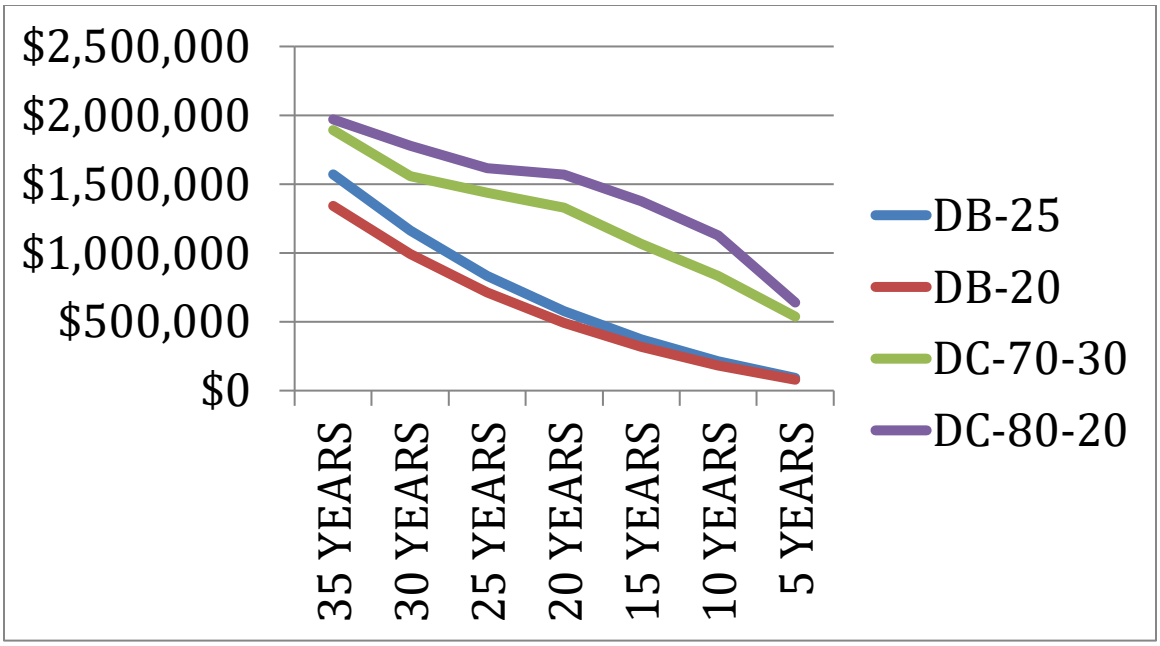

Figure 1

The uneven nature of the DC plan values arise from the randomness of the stock and bond market returns. The higher value of the DC plan accumulations come with the uncertainty that go with the market returns. The details are given Table 2. The average values for the DC plan accumulations are from 100 random simulations. For an employee with 35 years of service, the present value of DB pension plan is about $1.57 million for 25 years of pension and $1.34 million for 20 years of pension. The DC plan accumulation for an employee with 35 years of service averages to $1.89 million and 1.97 million respectively for the 70 percent stocks and the 80 percent stocks portfolios respectively. However, in 100 simulations, 47 (28) accumulations were less than the present values of 25 (20) years of pension. If one assumes normal distribution for the portfolio accumulations, the probability of the DC plan accumulations being lower than the pension benefit present values is 36 percent (25 years of pension) and 29 percent (20 years of pension).

The length of the service period is the critical determinant in the relative values of the benefits as well the uncertainty related to the benefits. For 25 years of service, the present value of DB plan pensions are: $0.83 million (25 years of pension) and $0.71 million (20 years of pension) with DC accumulation values at $1.44 million (70% stocks) and $1.62 million (80% stocks). The probability values for DB pensions coming out better than the DC accumulation come down to 24% (25 years of pension) and 20% (20 years of pension) with the 70% stock portfolio. The uncertainty of stock returns show in the higher probability values with 80% stocks portfolio: 27 percent (25 years of pension) and 23% (20 years of pension).

Overall, it is clear to see that for an employee with shorter service periods, DC plans provide much higher expected value, though with some uncertainty. It should be noted that for lower service periods, the level of uncertainty decreases. It should also be mentioned that while the total contribution to the DB plan is 15.5 percent of the salary, the DC plan studied in this paper gets only 10 percent contribution. Despite this higher level of contribution, the DB plan assets are underfunded to meet the liability of the pension benefits.

SUMMARY AND CONCLUSION

This paper analyzes the relative benefits of a proposed DC plan to replace the current DB plan for employees of a state university. We use two stock-bond portfolios and simulated market returns to estimate accumulated values of the DC plan contributions, which are compared to the present values of pension benefits from the current DB plan. The average values for the DC plan accumulations are higher than the comparable DB plan

benefits regardless of the length of the employee service period. The DC plan accumulations are, of course, subject to the vagaries of the investment returns, though this uncertainty is considerably lower as the employee service is shorter. In other words, DB plan appears better when one considers a long service period with the underlying, unstated, assumption of the risk-free nature of the DB plan.

The nature of the risk of pension benefits from a DB plan needs further analysis. It is clear that when financial markets perform poorly, the value of DB plan assets go down. Prolonged downturns in stock and bond returns have significant impact on DB plans and the benefits cannot be sustained without higher contributions from employers or employees or support from the state. If this element of risk in the DB plan benefits is taken into account, DC plans will appear to be less risky than perceived.

We simplify and make rather conservative assumptions with respect to another risk factor that goes with a defined benefit pension plan. This relates to the years of pension benefits. While we assume, rather generously, 25 years and 20 years of pension benefits, actual individual benefits are likely to be far less. In the event of the employee's early demise, the pension benefits will, in most cases, stop. This reduces the value of the DB plan benefits.

TABLE 2

YEARS OF EMPLOYMENT

DEFINED BENEFITS PLAN	35 YEARS	30 YEARS	25 YEARS	20 YEARS	15 YEARS	10 YEARS	5 YEARS
LAST FIVE YEARS SALARY	$128,867	$111,162	$95,889	$82,715	$71,350	$61,547	$53,091
ANNUAL PENSION	$90,207	$66,697	$47,944	$33,086	$21,405	$12,309	$5,309
DISCOUNT RATE FOR PV (PENSION)	3%	3%	3%	3%	3%	3%	3%
PV OF BENEFITS FOR 25 YEARS	**$1,570,782**	**$1,161,403**	**$834,864**	**$576,129**	**$372,730**	**$214,347**	**$92,449**
PV OF BENEFITS FOR 20 YEARS	**$1,342,047**	**$992,282**	**$713,292**	**$492,234**	**$318,454**	**$183,134**	**$78,987**
DEFINED CONTRIBUTION PLAN: SUMMARY OF SIMULATION RESULTS							
PORTFOLIO COMPOSITION - 70% STOCKS/30% BONDS							
VALUE OF DC PLAN: AVERAGE OF 100 SIMULATIONS	**$1,892,530**	**$1,558,206**	**$1,438,703**	**$1,328,393**	**$1,065,263**	**$835,035**	**$537,796**
NO. OF RUNS V(DC) < V(DB: 25)	47	40	29	9	4	7	2
NO. OF RUNS V(DC) < V(DB:20)	29	28	22	7	3	6	2
PROBABILITY OF V(DB: 25) >V(DC)	38.91%	32.97%	24.22%	14.18%	11.90%	12.67%	14.97%
PROBABILITY OF V(DB: 20) >V(DC)	31.50%	26.48%	20.04%	11.66%	10.16%	11.52%	14.25%
PORTFOLIO COMPOSITION - 80% STOCKS/20% BONDS							
VALUE OF DC PLAN: AVERAGE OF 100 SIMULATIONS	**$1,970,004**	**$1,777,109**	**$1,616,509**	**$1,567,494**	**$1,373,881**	**$1,128,371**	**$639,842**
NO. OF RUNS V(DC) < V(DB: 25)	43	37	24	14	6	4	2
NO. OF RUNS V(DC) < V(DB:20)	33	29	17	8	5	3	1
PROBABILITY OF V(DB: 25) >V(DC)	36.30%	35.54%	25.98%	22.41%	16.00%	16.03%	17.78%
PROBABILITY OF V(DB: 20) >V(DC)	29.07%	31.83%	22.84%	20.53%	14.73%	15.22%	17.19%

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