Assessing the Option Premium in Hybrid Pension Plans

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Abstract

Hybrid pension plans represent a combination of defined benefit and defined contribution plans and do not seem to have been treated in the literature at all.

This paper looks at one particular type of hybrid plan, namely the plan design whereby the benefit on retirement, termination or death is expressed as the greater of a defined benefit or defined contribution formula. In particular, the paper will indicate how to quantify the option premium in a relatively straightforward manner, and how the concepts can be conveyed to a lay audience of plan sponsors and plan members.

Keywords

Hybrid pension plans, option premium.

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1. Introduction

Many papers have been written on the asset liability management of defined benefit pension plans. Citing the AFIR literature alone, we have [1,2,3,4,5,6]

Defined contribution plans have a much more restricted literature. [7]

Hybrid pension plans represent a combination of defined benefit and defined contribution plans and do not seem to have been treated in the literature at all.

This paper looks at one particular type of hybrid plan, namely the plan design whereby the benefit on retirement, termination or death is expressed as the greater of a defined benefit or defined contribution formula. In particular, the paper will indicate how to quantify the option premium in a relatively straightforward manner, and how the concepts can be conveyed to a lay audience of plan sponsors and plan members.

2. Description of hybrid plans

There are two main types of hybrid plans:

- a linear combination of defined benefit and defined contribution, e.g. 1% non-contributory final average plan, plus the benefit that can be purchased by an accumulation of 5% of the member's salary; and

- a non-linear combination, e.g. a benefit expressed as being the greater of 2% final average formula or the benefit that can be purchased by an accumulation of 10% of the member's salary.

This paper will deal exclusively with the second, non-linear type of formula.

3. The option premium

While there are many variables involved in the design of a hybrid plan, we will assume that the plan conforms to the following general principles:

- the benefit on retirement is based on members' final average earnings and is indexed in some fashion

- the benefit and contribution rates are set such that there is a "cross-over" point somewhere in a member's mid-career.

This latter point means that, on reasonable actuarial assumptions, members below a certain age (say age 40) can expect to be better off under the defined contribution formula, whereas members above this age can be expected to be better off under the defined benefit formula.

Traditionally, such a plan would be valued by assuming just such a crisp cut-off age - members' expected benefits would be compared on a deterministic basis and the greater of the expected defined contribution accumulation or defined benefit amount would be taken as the appropriate value.

However, under a stochastic interest and inflation rate environment, some defined benefit members will turn out to be defined contribution beneficiaries and vice versa, and this change will always be more costly for the plan. The option premium is the expected cost of the excess of the stochastic model over the deterministic model.

4. The model

The traditional approach can be represented simply as:

$V_H = \max (V_{DB}, V_{DC})$

where,

V_H = value of hybrid plan

V_{DB}= value of defined benefit provision

(years of service x unit x final average salary x discount factor x annuity factor)

V_{DC} = value of defined contribution provision

(v^n x contribution rate x accumulation of future salary)

However, V_{DB} and V_{DC} are really the means of a distribution of outcomes, and the value of the hybrid plan is the mean of the joint distributions.

Therefore, the value of the hybrid plan under stochastic interest rates becomes a distribution of probabilities over a large number of scenarios of returns (between 300 and 1000 for every year). The process used is a simulation of annual returns from year of employment to year of retirement of an individual.

Assumptions needed are:

* expected inflation
* standard deviation of inflation
* expected real rate of return of asset classes
* standard deviation of asset classes
* correlation between asset classes, and between inflation and asset classes
* yields on bonds.

The benefit at retirement is then established as the maximum between the value of the defined benefit and defined contribution. Simulations are generated and results can then be ranked.

For example, the median result would represent the point where 50% of projected benefits are higher and 50% of projected benefits are lower.

Median V^{S}_{H} = Median over a large number of scenarios of max (V^{I}_{DC}, V^{I}_{DB})
where I represents the number of run

To simplify the approach we have assumed that:

- the option is available at retirement only (i.e. deaths and terminations are ignored); and
- the defined benefit provision is fixed.

5. Variables

The aim of the model was to find the overall level of cost. As well the model could be used to find the option premium for a variety of asset mixes, from "conservative" to "aggressive".

Another use could be to find out how good or bad performance would affect the expected cost and option premium.

6. Results

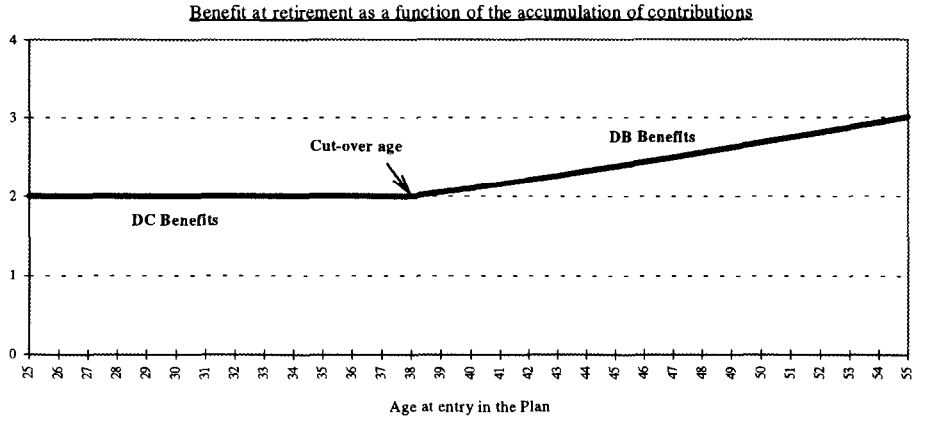
The retirement plan studied is the following:

Defined benefits portion: 1.5% of 3-year final average salary times years of membership indexed after retirement to inflation, with a cap of 3%.

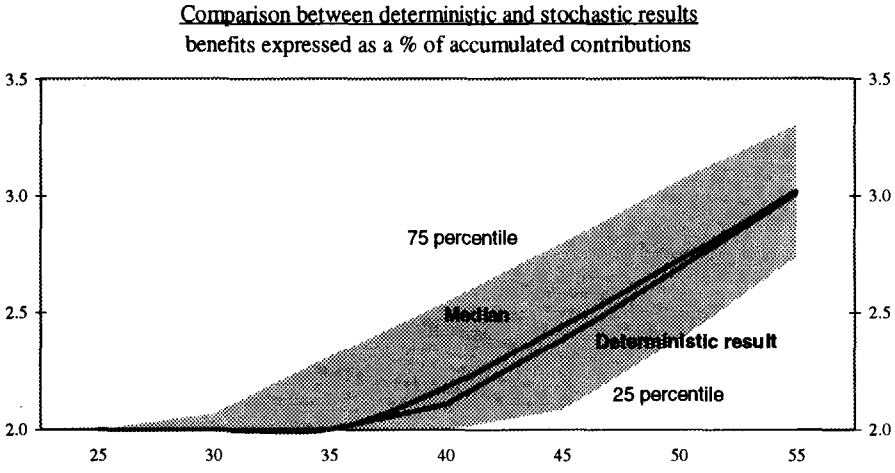
Defined contributions portion: indexed annuity purchased with the accumulation of 11% of salary (5.5% from participant and 5.5% from employer)

The first asset mix analysed is made up of 45% of fixed income securities and 55% of equities. Assumptions used are described in appendix.

First, on a deterministic basis, for various ages at entry in the plan, the graph below shows the benefits that will be received by the plan participant. Before age 38, the defined contributions plan is more attractive (the participant receives in fact twice the contribution he remitted to the fund), whereas after that the defined benefits plan is preferred. The assumed annual nominal rate of return of the fund was 9.2% (inflation at 3.5% and real return of the fund at 5.7%).

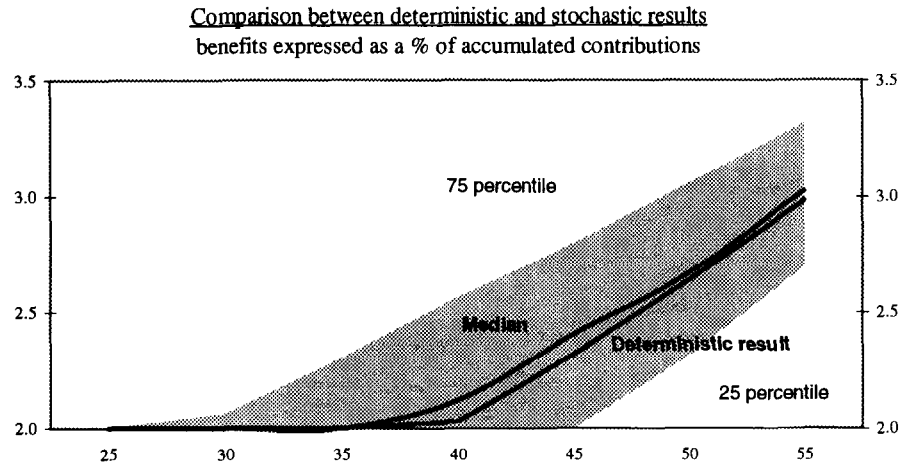


On a stochastic basis, an option premium appears, being the difference between the median result of the stochastic and deterministic projections:



For example, at age 40, the difference between the figures represents approximately 7% of the participant's total accumulated contributions. It could also be expressed as an additional contribution of 1% of annual earnings required from the employer. This could increase the cost of the overall plan.

If we explore a more aggressive asset mix, with 35% in fixed income securities and 65% in equities, the results are only slightly different. The results are more **volatile** (as we expected by increasing the equity content) and the distribution of outcomes is wider:



7. Comments and conclusions

Hybrid plans, where the benefit at retirement is expressed as the greater of a defined benefit or defined contribution accumulation are not uncommon in Canada, especially in the non-profit sector. In view of the lack of literature on these plans, it is probably safe to say that they were implemented with little investigation of the potential cost of this option feature. This paper has attempted to remedy this lack. It indicates that while the premium is not of such magnitude as to put the solvency of such plans into doubt, it is not inconsequential either.

The option premium has been assessed based on consideration of the median results. However, the 75th percentile results show considerably higher costs. Even the 75th percentile might not be considered a worst-case scenario. A "worst-case" scenario could therefore be considerably more costly than the assessment considered in this paper.

Finally, it would be instructive to use the model developed to test other aspects of this problem. For example, two asset mixes have been tested. It would be interesting to

review the results of other assets mixes, perhaps trying to find a mix that minimizes the option premium, perhaps at the cost of a reduced expected long term rate of return.

Another issue that is worth exploring is the effect of accumulated assets. The current exploration is based on age at entry only, i.e. assuming zero accumulated assets. It would be instructive to see how the option premium varied if the rate of return on past accumulated assets was either higher or lower than the expected median rate of return for the future. Again, this may indicate changes of asset mix depending on how successful past performance has been.

The authors welcome your comments and suggestions in regard to this research project.

Appendix - Assumptions used

The assumptions used for the projections of assets are the following:

Asset Class	Expected real return	Standard deviation
Short term investments	2.5%	4.0%
Fixed income securities	4.0%	9.0%
Canadian equities	7.0%	17.0%
U.S. equities	7.5%	17.5%
International equities	8.0%	20.0%

For inflation, the expected measure was 3.5% with a standard deviation of 2.5%. We assumed a serial correlation of 60% and began with an initial inflation of 2.5%. Yields of mid-term bonds were projected to simulate return of this asset class and to estimate the purchase price of an annuity (for the defined contributions plan). Returns of other asset classes were projected using a lognormal distribution.

The correlations between asset classes and inflation are:

	Inflation	Short term	Fixed Income	Cdn equities	U.S equities	Int'l equities
Inflation	1.0					
Short-term	-0.4	1.0				
Fixed Inc.	-0.4	0.5	1.0			
Cdn equit.	-0.1	0.1	0.1	1.0		
U.S equit.	-0.3	0.2	0.4	0.8	1.0	
Int'l equit.	-0.2	0.1	0.1	0.6	0.6	1.0

The two asset mixes studied:

Asset Class	First asset mix	Second asset mix
Short term investments	5%	5%
Fixed income securities	40%	30%
Canadian equities	39%	45%
U.S. equities	8%	5%
International equities	8%	15%

The specific assumptions for the participant:

Salary at entry:	$40,000
Annual increase in salary over inflation:	1%
Age at retirement:	60 years
Indexation of pension after retirement	Consumer Price Index increase subject to a cap of 3%

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