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Pension Asset Liability Management Model (ALM)

Jaka Permana[1], Rossi Peter Simanjuntak[2], Abiudin Gea[3], Liza Setyaning Pertiwi[4]

[1]Department of Mathematics, University of North Sumatera; Universitas Prima Indonesia (UNPRI), Jl.Sekip Medan

[2, 3, 4] Department of Mathematics, University of North Sumatera, Indonesia

Abstract: ***Procurement of pension assets to reduce benefits promises made by plan sponsors to participants and beneficiaries-in other words, the pension liabilities. Therefore the pension investment policy should be set in a way that explicitly integrates exposure to pension liabilities. The traditional approach to retirement investments have split factor the risk of liability, which has resulted in a portfolio which may be appropriate in assets, but which are subject to risk when evaluated relative to liabilities. efficient investment policy can be designed to avoid risks appreciated if exposure obligation explicitly integrated into investment frameworks. The intent of this writing there are two, namely to provide insight into the pension liability modeling, using the fundamentals and economics that affect the assets and pensions the obligation to provide a framework for a model assets and liabilities consistently.***

Keywords: Asset, Liability, Pension asset, ALM.

1. Introduction

Some pension sponsors have not explicitly integrated the pension liability's fundamental and economic exposures into the investment policy decision. Instead, their process has focused on setting appropriate "asset-only" portfolios. Such a process may be the current paradigm because the plan's contribution requirement, accounting cost, and balance sheet are all currently based on a smoothed relationship between assets and liabilities, mitigating the impact of a mismatch between the two. Thus, many plan managers select portfolios from the asset-only efficient frontier, relying on the actuarial and accounting smoothing to keep the relationship between assets and liabilities relatively stable over the short horizon.

Selecting portfolios from an asset-only perspective implicitly assumes that the liability has no risk at all—at least none that is market-related. By "market-related," we mean that the exposure is influenced by market-related factors, such as interest rates, inflation, or economic growth. However, pension liabilities, representing the present value of deferred wages, by their very nature are driven by economics and have many market-related exposures. Not integrating these exposures can result in inefficient investment policies when measured versus liabilities, as they may be exposed to excessive and unrewarded risk relative to liabilities. Such unrewarded risk was masked by the bull market of the 1990s, and subsequently unmasked by the storm of falling equity markets and interest rates that plagued the industry at the turn of the millennium. Couple this with the global pension regulatory environment trending toward unsmoothing pension assets and liabilities, and there is an increasing incentive to design investment policies that better integrate the exposures of assets and liabilities.

2. How to Define Risk?

Developing the appropriate investment benchmark depends on the relevant investment horizon for defining investment risk. If the plan sponsor defines risk as the risk that assets will not hedge the liability over the next year, then we must focus on short-term market-related liability exposures. This has been the focus of most advisors by using a portfolio of long-duration bonds to proxy the liability. This approach captures the liability's exposure to short-term changes of the term structure.

However, modeling the term structure exposure captures only part of the liability risk. Arnott and Bernstein (1988) state that "the size of pensions the corporation pays in future years will have little to do with today's level of long-term interest rates,"[2] and Bookstaber and Gold (1988) say "those who act as if the world were defined only by cash flows and interest rate exposure, duration and dedication, see only part of the asset/liability picture."[3]

Rather, in order to see the full picture of pension fund investment risk, one must also focus on the volatility of the estimated benefit payments themselves and how they change over time. An emphasis only on the short-term liability may be sensible for the relatively few financially weak companies with poorly funded plans. However, most companies are relatively healthy with well-funded ongoing plans, and they have the ability to focus on both long and short horizons.

For the relatively healthy company with an ongoing plan, risk is both the short-term volatility of plan costs and the long-term risk of pension assets being insufficient to defease the liability. Hence, liability modeling must deal with both horizons, and in particular, it must address the questions of what the liabilities will look like in the future, and how we can best mimic them as they evolve.

3. Pension Liabilities Decomposed

Again, pension liabilities vary in value like assets, and in order to measure investment risk relative to liabilities, we must understand how assets and liabilities are related. As for assets, the value of a liability can be determined in two steps:

1. Estimating the expected benefit payments, i.e., the future cash outflows and
2. Discounting them.

Liability risk is the volatility of its value and can be attributed to volatility in the discount rate and estimated benefit payments. Consistent with asset pricing, the discount rate used for the economic liability must reflect the market-related exposures of the benefit payments. For example, if the benefit payments increase with inflation, then the investment benchmark would have a real-rate bond component, and accordingly, the applicable discount rate should reflect the real-rate bond risk premium used by the market to discount inflation-linked cash flows. With respect to the underlying benefit payments, we focus on understanding their inherent fundamental and economic exposures. Pension benefits are not known with certainty. They exhibit volatility attributable to volatility in wages, inflation, and many nonmarket-related factors; they also exhibit growth attributable to future service costs and other nonmarket-related factors.

The extent and causes of the uncertainty in pension benefits vary greatly by demographic group. Thus, modeling the variations in estimated benefits is easiest by decomposing the benefits into demographic groups whose benefit levels are driven by different exposures. These exposures are either market-related or not. We address each in turn.

4. Setting Asset and Liability Sensitivities

The next step in the process requires setting the sensitivities of assets and liabilities versus the factors. Meder and Staub (2007) explain that the sensitivities describe how much the value of the assets and liabilities move in response to a move in the corresponding factor.

4.1 Assets

When determining the sensitivities of bonds, it is useful to set up a model:

$$V_B = \sum_t \frac{CF_t}{(1+r_t)^t},$$

where CF are the cash flows and r is the discount rate. To the extent that the cash flows are fixed (as in the case of a nominal bond), the value is sensitive to changes in the real rate, inflation, and nominal bond premium. If the cash flows are inflation-linked, as is the case with real-rate bonds, then the bond will not be sensitive to changes in inflation, since inflation affects the numerator and denominator in an offsetting way.

When modeling equities we utilize dividend discount models. According to the Gordon Growth Model, the intrinsic value of equity is

$$V_E = \frac{D}{s - g},$$

5. Results

where D is the annual dividend payment, r the discount rate, and g the growth rate of the dividends. Admittedly, the Gordon Growth Model in its basic form is too simplistic to picture reality. However, at this time we are concerned only with its didactic value for our purposes. In practice, the model may be more complex, if necessary.

4.2 Liabilities

Since People Corporation's plan does not provide for inflation indexation, the accrued benefits liabilities' cash flows will be fixed in a market-related sense. Visually the model for this portion of the liability looks identical to a bond.

$$V_{L\text{-}AB} = \sum_t \frac{B_t}{(1+r_t)^t}.$$

Essentially, we deal with a very long-term bond, and hence, the key risk is a change in the discount rate. People Corporation's future wage benefits are completely driven by wage inflation and real wage growth. In the case of s years until retirement, d years until demise and subsequent termination of the obligation, the intrinsic value of our future wages liability is

$$V_{L\text{-}FW} = \frac{B}{r - g} \cdot f,$$

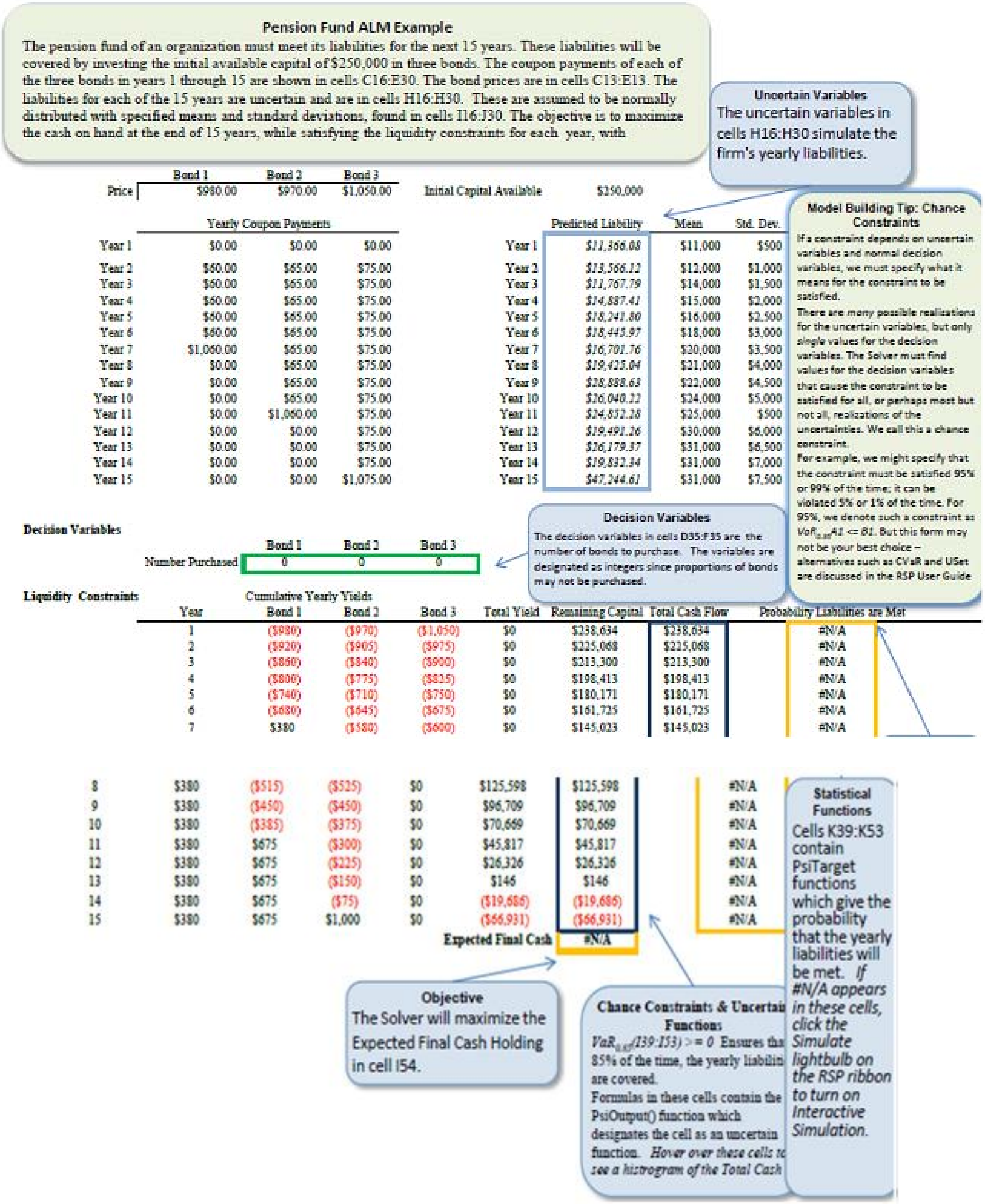
where

$$f = \frac{\left((1+g)^s - 1\right) \cdot \left((1+r)^{d-s} - 1\right)}{(1+r)^d},$$

r is the discount rate of the liability, and g the rate of growth. Comparing this with the present value of equity (4.2). One will notice that the liability has the same core structure as equity but also includes a correction factor.

As mentioned earlier, future wage benefits can be bifurcated into two components—future wage inflation and future real wage growth. In a market-related sense, the future wage inflation is completely driven by the actual inflation between now and each active employee's retirement. If People Corporation's plan provided for inflation indexation, the cash flow stream would almost exactly mimic the cash flow stream of real-rate bonds. But inflation linkage exists only between now and retirement. Therefore, for active participants, the closer to retirement they are, the more certain and similar to nominal bonds are the cash flows.

The final piece of information we need is an estimate of the residual risks, or what we call liability noise in the case of liabilities. When estimating liability noise, we know that the accrued benefits liability is less noisy than the future wages liability. However, the focus of the paper is not on quantifying the liability noise (Meder and Staub, 2007).



Pension Fund ALM Example

The pension fund of an organization must meet its liabilities for the next 15 years. These liabilities will be covered by investing the initial available capital of $250,000 in three bonds. The coupon payments of each of the three bonds in years 1 through 15 are shown in cells C16:E30. The bond prices are in cells C13:E13. The liabilities for each of the 15 years are uncertain and are in cells H16:H30. These are assumed to be normally distributed with specified means and standard deviations, found in cells I16:J30. The objective is to maximize the cash on hand at the end of 15 years, while satisfying the liquidity constraints for each year, with

Uncertain Variables
The uncertain variables in cells H16:H30 simulate the firm's yearly liabilities.

	Bond 1	Bond 2	Bond 3		
Price	$980.00	$970.00	$1,050.00	Initial Capital Available	$250,000

Yearly Coupon Payments	Bond 1	Bond 2	Bond 3		Predicted Liability	Mean	Std. Dev.
Year 1	$0.00	$0.00	$0.00	Year 1	$11,366.08	$11,000	$500
Year 2	$60.00	$65.00	$75.00	Year 2	$13,566.12	$12,000	$1,000
Year 3	$60.00	$65.00	$75.00	Year 3	$11,767.79	$14,000	$1,500
Year 4	$60.00	$65.00	$75.00	Year 4	$14,887.41	$15,000	$2,000
Year 5	$60.00	$65.00	$75.00	Year 5	$18,241.80	$16,000	$2,500
Year 6	$60.00	$65.00	$75.00	Year 6	$18,445.97	$18,000	$3,000
Year 7	$1,060.00	$65.00	$75.00	Year 7	$16,701.76	$20,000	$3,500
Year 8	$0.00	$65.00	$75.00	Year 8	$19,425.04	$21,000	$4,000
Year 9	$0.00	$65.00	$75.00	Year 9	$28,888.63	$22,000	$4,500
Year 10	$0.00	$65.00	$75.00	Year 10	$26,040.22	$24,000	$5,000
Year 11	$0.00	$1,060.00	$75.00	Year 11	$24,852.28	$25,000	$500
Year 12	$0.00	$0.00	$75.00	Year 12	$19,491.26	$30,000	$6,000
Year 13	$0.00	$0.00	$75.00	Year 13	$26,179.37	$31,000	$6,500
Year 14	$0.00	$0.00	$75.00	Year 14	$19,832.34	$31,000	$7,000
Year 15	$0.00	$0.00	$1,075.00	Year 15	$47,244.61	$31,000	$7,500

Model Building Tip: Chance Constraints
If a constraint depends on uncertain variables and normal decision variables, we must specify what it means for the constraint to be satisfied.
There are many possible realizations for the uncertain variables, but only *single* values for the decision variables. The Solver must find values for the decision variables that cause the constraint to be satisfied for all, or perhaps most but not all, realizations of the uncertainties. We call this a chance constraint.
For example, we might specify that the constraint must be satisfied 95% or 99% of the time; it can be violated 5% or 1% of the time. For 95%, we denote such a constraint as $VaR_{0.95}A1$ <= B1. But this form may not be your best choice – alternatives such as CVaR and USet are discussed in the RSP User Guide

Decision Variables

	Bond 1	Bond 2	Bond 3
Number Purchased	0	0	0

Decision Variables
The decision variables in cells D35:F35 are the number of bonds to purchase. The variables are designated as integers since proportions of bonds may not be purchased.

Liquidity Constraints

Year	Cumulative Yearly Yields Bond 1	Bond 2	Bond 3	Total Yield	Remaining Capital	Total Cash Flow	Probability Liabilities are Met
1	($980)	($970)	($1,050)	$0	$238,634	$238,634	#N/A
2	($920)	($905)	($975)	$0	$225,068	$225,068	#N/A
3	($860)	($840)	($900)	$0	$213,300	$213,300	#N/A
4	($800)	($775)	($825)	$0	$198,413	$198,413	#N/A
5	($740)	($710)	($750)	$0	$180,171	$180,171	#N/A
6	($680)	($645)	($675)	$0	$161,725	$161,725	#N/A
7	$380	($580)	($600)	$0	$145,023	$145,023	#N/A
8	$380	($515)	($525)	$0	$125,598	$125,598	#N/A
9	$380	($450)	($450)	$0	$96,709	$96,709	#N/A
10	$380	($385)	($375)	$0	$70,669	$70,669	#N/A
11	$380	$675	($300)	$0	$45,817	$45,817	#N/A
12	$380	$675	($225)	$0	$26,326	$26,326	#N/A
13	$380	$675	($150)	$0	$146	$146	#N/A
14	$380	$675	($75)	$0	($19,686)	($19,686)	#N/A
15	$380	$675	$1,000	$0	($66,931)	($66,931)	#N/A
					Expected Final Cash	#N/A	

Statistical Functions
Cells K39:K53 contain PsiTarget functions which give the probability that the yearly liabilities will be met. *If #N/A appears in these cells, click the Simulate lightbulb on the RSP ribbon to turn on Interactive Simulation.*

Objective
The Solver will maximize the Expected Final Cash Holding in cell I54.

Chance Constraints & Uncertai
Functions
$VaR_{0.85}(I39{:}I53) >= 0$ Ensures tha 85% of the time, the yearly liabiliti are covered.
Formulas in these cells contain the PsiOutput() function which designates the cell as an uncertain function. *Hover over these cells to see a histrogram of the Total Cash*

6. Conclusion

ALM problems is more realistic than the current standard immunization method. However, SP models because computational complexity, only until that SP has been able to applied in the industry. However, some simplification such as rule-making often needed in its implementation. Programming stochastic rely on ALM the uncertainty is modeled through a series discrette scenario. Although there has been some work on the effects of distribution stable in SP, application ALM and case studies have been quite limited in joining various characteristic financial time-series. It is known that the GARCH and methods of time-series. Other create a scenario very much expects volatility conditional on the period of time that far. This creates a problem because the model ALM must cover scenarios far into the future. In the ALM models, it seems more appropriate to generate scenarios in accordance with past volatility front implied by the data market. This is an area of research that is being continues: build tree scenarios using historical time series, such as GARCH is stable, for a period an earlier time, but produce a scenario for long time and then that will be implemented on market data.

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