Linking Pension Liabilities to Assets

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Pension assets exist to defease the benefit promises made by plan sponsors to participants and beneficiaries—in other words, the pension liability. It follows that pension investment policies should be set in a way that explicitly integrates the exposures of the pension liability. The traditional approach to pension investing has excluded the risks of the liability, which has resulted in portfolios that may be appropriate in an asset-only framework, but that are exposed to unrewarded risk when evaluated relative to liabilities. Efficient investment policies can be designed to avoid unrewarded risk if the exposures of the liability are explicitly integrated into the investment framework.

The intent of this paper is twofold:

- To provide insight into modeling the pension liability, and focus on which fundamental and economic factors influence its evolution.
- Using the fundamental and economic factors that influence both assets and the pension liability, to provide a framework to model assets and liabilities consistently.

While we focus on pension plans, the general framework put forth to link assets and liabilities via fundamental and economic factors is applicable to many situations where assets are set aside to defease a future obligation that has market-related exposures. Thus, the framework can be generalized to insurance products, postretirement health benefits, or college savings plans.

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.

Hence, in our investment framework, we allow for an economic liability.[1] This framework fundamentally changes the picture in that assets that mirror the economic liability (which becomes the investment benchmark) are considered low risk. Table 1 summarizes the fundamental difference between designing policies with an asset-only perspective versus a liability-relative perspective.

Table 1: Traditional asset only approach vs. liability relative approach

	Asset-only	**Liability-relative**
Objective	Achieve asset return target	Outperform liabilities
Low risk investments	Cash	Liability mimicking asset portfolio
Investment benchmark	Policy portfolio	Liability mimicking asset portfolio

Clearly, implementing an investment framework where the liability is the benchmark requires a comprehensive understanding of the liability exposures. Unfortunately, there is no investable asset that perfectly mimics the exposures of a pension liability. As a result we must create the investment benchmark by constructing a portfolio of assets that best mimics the liability.

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.

[1] The concept of an economic liability is not new. There is much literature in support of an economic view of the liability, e.g., Treynor et al. (1976), Bookstaber and Gold (1998), Arnott and Bernstein (1998), Ryan and Fabozzi (2002), and most recently Waring (2004) are examples; for detailed references, see the end of this paper.

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. To put our approach in perspective, we will focus on a hypothetical defined benefit plan of People Corporation Inc., which has a typical liability profile and typical plan provisions.

As for assets, the value of a liability can be determined in two steps:

- Estimating the expected benefit payments, i.e., the future cash outflows and
- 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.

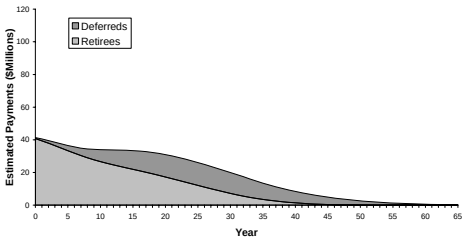
The extent and causes of the uncertainty in pension benefits vary greatly by demographic group. Thus, modeling the variations in estimated benefits is easiest by decomposing the benefits into demographic groups whose benefit levels are driven by different exposures. These exposures are either market-related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

4. Market-Related Exposures

4.1 Inactive Participants

These are the benefits attributable to participants currently receiving pension payments (retirees), or participants who are no longer working for the firm and are owed a benefit, but have not yet started receiving benefit payments (deferreds). The estimated benefit payments to this group are fixed, in a market-related sense, unless they are indexed with inflation in order to protect the retiree's standard of living. Figure 1 shows People Corporation's estimated future inactive benefit payments

Chart 1: Inactive benefits



Source: UBS Global Asset Management

People Corporation's plan does not provide inflation indexing. Therefore, the inactive benefit payments are fixed, and hence the value of these benefit payments are very "bond-like" with the only market exposure being the exposure to the term structure. The portfolio of assets that best mimics such a liability is a bond portfolio whose cash flows match the estimated benefit payments. On the other hand, if the benefit payments are indexed with inflation, the benefit payments, and thus the value of the liability, will vary with the

[2] See Arnott et al. (1988), p. 102.
[3] See Bookstaber et al. (1988), p. 71.

level of inflation. In this case, the investment benchmark is a mixture of real-rate bonds and nominal bonds. If the plan provides full one-for-one inflation indexation, the benchmark for this portion of the liability is 100% inflation-linked bonds.

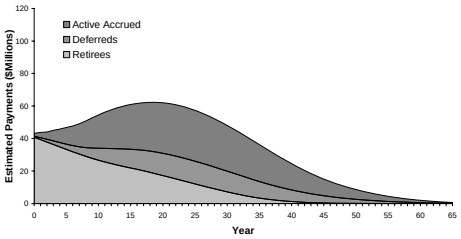
4.2 Active participants

Here we look at the estimated benefit payments associated with currently active employees. When modeling these benefit payments, we slice the estimated benefit payments into two components: benefits attributable to past service rendered and current wages (accrued benefits), and benefits attributable to future service and future wages (future benefits).

4.2.1 Accrued benefits

These are benefits attributable to past service rendered and current wages. Like inactive benefits, they are fixed in a market-related sense, unless they are indexed with inflation in order to protect the participant's standard of living. Consistent with People Corporation's inactive benefits, there is no inflation indexation, and therefore the investment benchmark will consist of nominal bonds. The present value of these benefits plus the inactive benefits represents the plan's accrued benefits liability. Figure 2 shows People Corporation's estimated benefit payments attributable to accrued benefits.

Chart 2: Accrued benefits



Source: UBS Global Asset Management

4.2.2 Future Benefits

Future benefits are benefits attributable to future wages to be earned and future service to be rendered. These benefits drive the evolution of the liability over the long term, but they will have very little impact on the pension plan's overall liability in the short term. For many plans, these benefits will dominate the liability 20 years from now. To the extent that these benefits are included in the plan's funding target, and capital market driven (have a determinable correlation with assets), they need to be considered today when determining the investment benchmark.

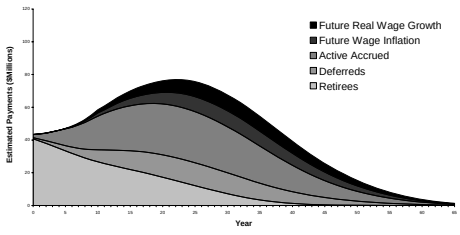
For frozen pension plans, the liability attributable to future benefits is zero and therefore does not need to be considered.[4] That is, for frozen plans, the accrued benefit liability is the ultimate liability of the plan and has market exposures that are best mimicked by a combination of nominal and index-linked bonds.

4.2.2.1 Future Wages

People Corporation's plan, along with many other plans, provides benefits that are tied to an employee's wages. Assuming a certain rate of future wage increases, the actuary provides an estimate of benefit payments attributable to future wage increases. We will call the present value of these estimated benefit payments the future wages liability. In many countries the funding target is set equal to the accrued benefits liability plus the future wages liability, and therefore is the relevant investment benchmark. Using accounting nomenclature, the accrued benefits liability plus the future wages liability is analogous to the projected benefit obligation in the United States under FAS 87 and the defined benefit obligation internationally under IAS19.

People Corporation assumes future wage increases of 4% per annum. These wage increases and the corresponding benefits are attributable to two economic forces: wage inflation and real wage growth. People Corporation assumes 2% wage inflation and 2% real wage growth. Figure 3 shows its estimated benefit payments attributable to accrued benefits plus the future wage increases, split between future wage inflation and future real wage growth.

Chart 3: Accrued benefits plus future wage benefits



Source: UBS Global Asset Management

4.2.2.1.1 Future Wage Inflation

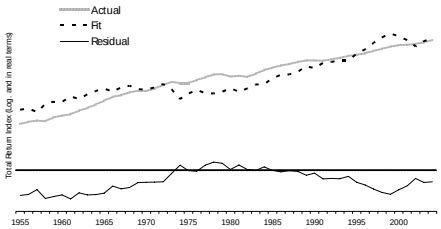
There is a long-term relationship between general inflation and wage inflation. Thus, cash flows of real-rate bonds will vary similarly to the variations in the estimated benefit payments attributable to future wage inflation. However, People Corporation's wage inflation benefits for each active employee are exposed to inflation only until retirement. After retirement these benefit payments are fixed and no longer exposed to changes in inflation. As a result, a combination of real-rate bonds and nominal bonds will be the

investment benchmark for People Corporation's wage inflation liability.

4.2.2.1.2 Future Real Wage Growth

Real wage growth is linked with economic growth through labor's share of productivity increases. There is strong evidence for a stable share of labor in national income.[5] In other words, the real wage growth is linked with productivity increases. Equity earnings and dividends are also related to economic growth; therefore we expect a stable long-term relationship between the stock market and the GDP.[6] In order to portray this relationship, we regress the real US GDP on the real S&P 500, in Figure 4, and find the following:[7]

Chart 4: GDP regressed on the S&P 500



Source: Bureau of Economic Analysis, Bureau of Labor Statistics, Standard & Poor's

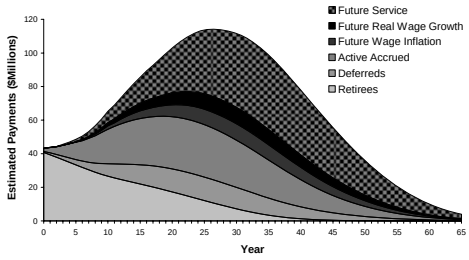
Very high *t*-statistics of 14 for the intercept and 27 for the slope, and an R^2 of 92% are evidence for a strong long-term relationship. However, this is not striking news, as there is much literature in support of this.[8]

Just like People Corporation's wage inflation benefits, its real wage growth benefits for each active employee are exposed only to real wage growth until retirement. After retirement these benefit payments are fixed and no longer exposed to changes in growth. As a result, a combination of equities and nominal bonds will be the investment benchmark for People Corporation's real wage growth liability.

4.2.2.2 Future Service Rendered

To the extent that it is currently funded and capital-market driven, we can expand our definition of the liability by including the benefit payments attributable to future service to be rendered. These are shown for People Corporation in Figure 5.

Chart 5: Accrued benefits plus future wages plus future service



Source: UBS Global Asset Management

Just like the volatility of future wage benefits, the volatility of future service benefits is linked to wage growth. As wages grow, the service accruals granted will be based on higher wages, and thus the corresponding benefit payment will be higher. But in reality this portion of the liability is often not included in the funding target and, therefore, usually currently not funded. Hence, we exclude it from the investment benchmark.

Table 2 summarizes the market-related exposures and corresponding liability-mimicking assets for People Corporation.

Table 2: People Corporation's liability mimicking assets

Portion of the Investment Benchmark	Market-Related Exposures	Liability Mimicking Assets
Inactive	Term Structure	Nominal Bonds
Active - Accrued	Term Structure	Nominal Bonds
Active - Future Wage	Inflation	Real Rate Bonds
	Growth	Equities
	Term Structure	Nominal Bonds

[5] See Singer and Terhaar (1997), p.19.
[6] More precisely, we expect the stock market to anticipate the economy.
[7] The data series consists of annual observations.
[8] See, e.g., Campbell, Lo, and MacKinlay (1997) or Fama and French (1998).

5. Nonmarket-Related Exposures: Liability Noise

As mentioned above, the estimated benefit payments have both market-related and nonmarket-related exposures. We call the uncertainty in benefit payments attributable to non–market-related exposures "liability noise." There are two components of liability noise:

- Noise around the model—plan demographic experience differing from the actuary's model, given that the underlying probabilities are known with certainty and
- Model uncertainty—the fact that the underlying probabilities are not known with certainty (e.g., mortality assumption change due to medical innovations).

With respect to the noise around the model, the main factor that drives the liability noise is the number of participants. Statistical methods can be used to estimate this component of noise; the larger the plan's population the more closely experience will track the model.[9] On the other hand, model uncertainty, by its very nature, is difficult to estimate. The extent and causes of the liability noise vary greatly by demographic groups. We address inactive participants, and then active participants.

5.1 Inactive Participants

For retirees, liability noise is attributable to one major source. Embedded within the actuarial projection of benefit payments is a mortality assumption about the length of people's lives, and hence the length of time they will be receiving benefits. To the extent that mortality experience differs from what was assumed, the benefit payments will vary accordingly. If people live longer than assumed, benefit payments will be larger, and if people live shorter than assumed, benefit payments will be smaller. At this point in time there are few liquid assets whose cash flows are linked with mortality. Thus, mortality exposure is currently difficult to hedge. However, there are bonds under development where the coupons are inversely linked to mortality, and an index linked to U.S. life expectancy has recently been developed.

In addition to longevity risk, a deferred's estimated benefits are based on an assumption about when the participant will retire and start receiving benefits. The sooner the participant elects to receive benefits, the smaller the annual benefit the plan provides, as the participant is expected to receive it for a longer time. Thus, the uncertainty regarding the timing and amount of benefits coupled with mortality risk results in deferred liabilities being noisier and less hedgeable than retirees' liabilities.

5.2 Active Participants

In addition to a mortality assumption, active employees' estimated benefit payments are embedded with assumptions of withdrawal, disability, and retirement, and therefore are embedded with a large amount of uncertainty, much more so than those of retirees or deferreds. The estimated benefit payments for an employee who is many years away from retirement are based on a long string of probabilities and represent the actuary's best estimate regarding the plan's future obligation. Although we cannot hedge the noise, the smaller the plan, the greater the liability noise, and the less hedgeable the liability.[10]

6. Linking Assets and Liabilities via Fundamental Factors

As suggested above, pension liabilities have many market-related and nonmarket-related exposures. Based on the discussed exposures, we hypothesize that People Corporation's investment benchmark is some combination of nominal bonds, real-rate bonds, and equities. These are the cornerstone liability mimicking assets. The crucial question is: What is their appropriate combination? Using the economic and fundamental factors that underlie asset and liability values, we can formally link liabilities and assets and determine the investment benchmark.

We have demonstrated that the accrued benefits liability has primarily market-related exposures to shifts in the discount rate, and thus the relevant factor is the term structure, which entails the real rate, inflation, and a nominal bond premium. Further, the future wages liability is exposed to the change in wage level, and thus, economic growth and inflation. To the extent that the future wages liability is linked with economic growth, equity growth is a relevant factor as well. Finally, if the plan provides for some inflation indexation, the liability has some similarity with real-rate bonds, and thus is exposed to changes in the real-rate bond premium.

On the other hand, the economic and fundamental factors underlying the cash flows provided by the assets are the real risk-free rate of return, the rate of inflation, the corresponding risk premia, and, in the case of equity, the rate of growth.

With these factors in mind, we are ready for factor modeling. In a first step to that end, we

[9] Leibowitz et al. (1991) estimate the this component of liability noise "would range from 2% to 3% for small group ($10 million liability) to just a small fraction of 1% for a liability of $1 billion." p. 68.
[10] Leibowitz et al. (1991) claim that liabilities with noise in excess of 10% "offer little practical assistance in surplus management." p. 69.

determine the factors involved. The Capital Asset Pricing Model (CAPM) holds that an asset's fair return (expected return) entails the risk-free rate of return as a compensation for consumption deferral plus a risk premium commensurate with the asset's risk. Further, the risk-free rate can be disaggregated into the compensation for inflation and the real risk-free rate of return.

In practice, inflation is proxied by the change of the consumer price index (CPI), and the real risk-free rate is proxied by the T-bill return minus the inflation proxy. With regard to the risk premium, historical analysis, often combined with a forward-looking adjustment, helps to determine the risk premium as the difference between the asset's total return and the risk-free rate. Further, with regard to growth, we believe in a long-term relationship between the overall economy and the stock market.

Since assets and liabilities represent economic values, they can be modeled with the same underlying factors, as the above description implies. Table 3 shows our suggested factor covariance matrix, disaggregated into a correlation matrix and a column of standard deviations, that is, it describes the relationships between the factors.

7. Setting Asset and Liability Sensitivities

The next step in the process requires setting the sensitivities of assets and liabilities versus the factors. The sensitivities describe how much the value of the assets and liabilities move in response to a move in the corresponding factor.

7.1 Assets

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

$$V_B = \sum_t \frac{CF_t}{(1+r_t)^t}, \qquad (7.1)$$

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

$$V_E = \frac{D}{r - g}, \qquad (7.2)$$

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.

From these valuation formulas, we can derive the sensitivities versus the underlying factors. As an example, consider bonds with a maturity of five years and a par yield of 5.5%. If the actual short-term risk-free rate moves by 100 basis points, the yield of a 5-year bond usually moves by less since

- The 5-year yield is a function of the actual short-term risk-free rate and all expected future short-term rates (i.e., the forward rates); and

- There is no information about the future short-term rates, as they are further out. Hence, the market assumes they are close to their average, that is, it anticipates mean reversion.

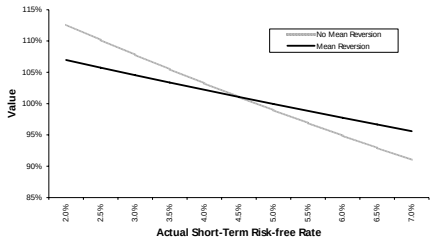
In Figure 6 the first case assumes that all expected future short-term rates move exactly by the same amount as the actual short-term risk-free rate, while in the second case, we assume that they still move in the same direction but by a decreasing amount the further out they are.

That is, the second case suggests that the market assumes mean reversion, while the first case does not. Since mean reversion mitigates the impact of a move of the actual short-term risk-free rate on the resulting discount rate, the corresponding bond value function is flatter than in the case where the market does not assume mean reversion: We infer a decrease in bond value of approximately 2% in response to a 1% increase of the short-term rate.

Table 3: Risk and correlation of fundamental factors

	Risk	Real Rate	Inflation	Growth	Equity premium	Nominal bonds premium	Real bonds premium
Real Rate	0.80%	1.00		0.20	0.10	0.05	0.05
Inflation	0.80%		1.00	-0.10	0.20	0.20	
Growth	1.00%	0.20	-0.10	1.00	-0.10	0.10	0.05
Equity premium	1.00%	0.10	0.20	-0.10	1.00	0.40	0.30
Nominal bonds premium	0.66%	0.05	0.20	0.10	0.40	1.00	0.85
Real bonds premium	0.40%	0.05		0.05	0.30	0.85	1.00

Chart 6: Bond Sensitivity vs. Risk-free Rate



Source: UBS Global Asset Management

7.2 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.

$$V_{L\text{-}AB} = \sum_t \frac{B_t}{(1+r_t)^t}. \qquad (7.3)$$

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

$$V_{L\text{-}FW} = \frac{B}{r-g}.f, \qquad (7.4)$$

where

$$f = \frac{\left((1+g)^s - 1\right)\cdot\left((1+r)^{d-s} - 1\right)}{(1+r)^d}, \qquad (7.5)$$

r is the discount rate of the liability, and *g* the rate of growth. Comparing this with the present value of equity (7.3), 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. We approximate the active population's time to retirement by using the average future service calculated by the actuary; for People Corporation's plan it is 11 years. Any change in inflation from the assumed rate (2% in People Corporation's case) would compound itself on average for 11 years, if the change in inflation persisted that long. However, our model suggests that the market anticipates inflation to revert over the medium term, that is, in less than 11 years. Based on our model, inflation changes have a muted impact on the assets and the liability.

Just like the future wage inflation component, the real wage growth component is not driven indefinitely by real wage growth. Future real wage growth applies only until retirement. Again, we use the average future service to approximate the sensitivity of these cash flows to changes in future real wage growth. The key difference here is that we expect changes in growth to persist longer than we assume for inflation, and this expectation is reflected in a higher sensitivity.

With regard to the discount rate, we recognize that the cash flows in the case of future real wage growth are equity-linked prior to retirement and fixed thereafter. As a result, the cash flows are similar to both equities and bonds, and thus their corresponding discount rate should reflect both the bond premium and the equity premium.

The sensitivity matrix above turns out to be as shown in Table 4

Table 4: Sensitivity of assets and liabilities to changes in fundamental factors

	Real rate	Inflation	Growth	Equity Premium	Nominal bonds premium	Real bonds premium
Liability - accrued benefit	-400%	-200%			-1000%	
Liability - wage inflation	-600%				-600%	-1200%
Liability - wage growth	-600%	-200%	1200%	-1200%	-600%	
Equity	-400%	-200%	1000%	-1000%		
Nominal bonds	-200%	-200%			-550%	
Real bonds	-200%					-500%

Table 5

	Risk	Liability-accrued benefit	Liability-wage inflation	Liability-wage growth	Equity	Nominal bonds	Real bonds
Liability - accrued benefit	8.0%	1.00	0.93	0.48	0.31	0.99	0.83
Liability - wage inflation	9.9%	0.93	1.00	0.42	0.24	0.87	0.97
Liability - wage growth	19.8%	0.48	0.42	1.00	0.98	0.50	0.37
Equity	15.4%	0.31	0.24	0.98	1.00	0.33	0.22
Nominal bonds	4.6%	0.99	0.87	0.50	0.33	1.00	0.76
Real bonds	2.6%	0.83	0.97	0.37	0.22	0.76	1.00

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, and for this example, we assume People Corporation's liabilities have no residual risk.[11]

8. Results

At this point, we have all the necessary ingredients to calculate the risks of assets and liabilities and their mutual correlations.[12] Based on our parameters, we find the covariance matrix as shown in Table 5.

Most important, as the derived covariance matrix demonstrates, while the accrued benefit liability is highly correlated with nominal bonds, the future wages liability is highly correlated with equity and real-rate bonds. This is in line with our previous recommendation: Accrued benefits can be mimicked best with a combination of nominal bonds, and the most appropriate mimicking assets for the future wages liability are equity and real-rate bonds; the reason for this are the joint growth and inflation components.

Recombining the decomposed liability and the corresponding mimicking assets, we get the following liability mimicking asset portfolio for People Corporation's pension fund.

Table 6: People Corporation's liability mimicking asset portfolio

	Nominal Bonds	Real Rate Bonds	Equities
Liability mimicking asset portfolio	80%	10%	10%

The allocation of People Corporation's liability-mimicking asset portfolio is representative of their typical pay-related liability profile. However, the resulting allocation is sensitive to many liability structural factors, including the proportion of the future wages liability to the overall liability, the degree of inflation indexation, and the status of the plan (e.g., ongoing, closed, or frozen). For example, if the fund was less mature and/or had a higher proportion of future wages liability, there would be a higher allocation to equities and real-rate bonds. If the plan offered full one-for-one inflation indexation via a cost-of-living adjustment (COLA), one would see the nominal bonds replaced with real-rate bonds. And, if the plan was frozen and therefore no longer had any exposures to future wage growth, there would be no real-rate bonds or equities, only nominal bonds.

9. Designing Investment Policies Relative to Liabilities

People Corporation could invest in this liability-mimicking portfolio, and this would be the low-risk investment. This means that investing in this portfolio results in the best chance of tracking the liability as it grows and evolves over time. In addition, this is also the appropriate investment benchmark. If the return on the fund's assets beats the return on the liability-mimicking asset portfolio, all stakeholders should be satisfied since the current pension promises will be paid.

However, by definition, investing in the liability-mimicking portfolio will not provide an expected return in excess of the liability, and therefore future service benefits would be defeased by future cash contributions.

Often this low-risk strategy will be too expensive for plan sponsors to maintain over the long run. Therefore, in most cases, we do not recommend investing in the low-risk portfolio, but only measuring investment risk against it. The challenge is to find the most efficient way to allocate more assets to "higher returning" asset classes such as equities, while minimizing the amount of uncompensated risk taken versus the liability. This can be approached in two steps:

1. Hedge the uncompensated liability risks. Derivatives can be used to synthetically represent the market-related exposures of the liability-mimicking asset portfolio. For example, interest rate derivatives can be used to mimic the term structure exposure of the liability—the liability's largest risk factor. And, utilizing

11 Ezra (1991) estimated the noise for a liability consisting of accrued benefits and the future wages to be 7%. This estimate is attained by modeling the liability as a bond.
12 See Staub (2006) for an in-depth analysis on factor-based covariance matrix modeling.

derivatives to hedge requires far less capital than cash investment, thus freeing up capital to be invested in “higher returning” assets.

2. Generate return. Focus the remaining capital on efficient return generation. This can be done within an asset-only framework, because once the liability has been hedged, assets should not be given “credit” for further hedging.

This liability-relative approach often leads to different investment policies than the traditional asset-only approach. The traditional approach typically leads to 60–70% equities, with the remainder in short- and medium-duration nominal bonds. The liability-relative approach, on the other hand, leads to investing in long-duration bonds, a small allocation to equities, and interest rate derivatives to hedge the liability, with the remainder invested in a well-diversified return-focused component.

10. Conclusion

The recent poor performance of pension plan assets versus liabilities has called into question the traditional approach to measuring investment performance—the asset-only framework. This has brought about an increasing emphasis on measuring pension fund performance relative to what really matters—the plan’s liabilities. Utilizing this framework can help plans avoid uncompensated investment risk versus liabilities like those experienced at the beginning of the decade.

Measuring risk relative to liabilities requires modeling of the liability and understanding the liability’s market-related exposures. Many practitioners to date have taken an overly simplistic approach by modeling the liability as a short position in a long-duration bond. Such an approach focuses on short-term changes in the term structure used to discount the expected benefit payments, but does not capture the expected benefit payments exposures to inflation and economic growth.

The long-term relationship between the GDP and the equity market is important for considerations such as pension fund liabilities. Since pension liabilities represent deferred wages, the future value of benefit payments is exposed to future economic growth and inflation. Therefore, for the majority of plans we believe that the low-risk investment benchmark consists of mostly long-duration bonds with the remainder in equities.

Thus, a liability is indeed more complicated than a long-duration bond, and factoring in exposures to economic growth and inflation allows for a more robust measurement of liability relative to investment risk and performance.

Finally, when most sponsors take investment risk relative to liabilities, this can be done most efficiently by first constructing the liability-mimicking asset portfolio with the aid of derivatives and then focusing the remaining capital on efficient return generation.

References

Arnott, Robert D., and Peter L. Bernstein. 1988. The Right Way to Manage Your Pension Fund. *Harvard Business Review*, January-February.

Bookstaber, Richard, and Jeremy Gold. 1988. In Search of the Liability Asset. *Financial Analyst Journal* January-February.

Campbell, John Y., Andrew W. Lo, and A. Craig MacKinlay. 1997. *The Econometrics of Financial Markets*. Princeton: Princeton University Press.

Ezra, D. Don. 1991. Asset Allocation by Surplus Optimization. *Financial Analyst Journal*, January-February.

Fama, Eugene, and Kenneth French. 1988. Dividend Yields and Expected Stock Returns. *Journal of Financial Economics* 22.

Leibowitz, Martin L., Stanley Kogelman, and Lawrence Bader. 1991. Asset Performance and Surplus Control: A Dual Shortfall Approach. New York: Salomon Brothers, July.

Ryan, Ronald J., and Frank J. Fabozzi. 2002. Rethinking Pension Liabilities and Asset Allocation. *Journal of Portfolio Management*, Summer.

Singer, Brian D., and Kevin Terhaar. 1997. Economic Foundations of Capital Market Returns. CITY: Research Foundation of the Institute of Chartered Financial Analysts.

Staub, Renato 2006. Multilayer Modeling of a Market Covariance Matrix. *The Journal of Portfolio Management*, Spring 2006.

Treynor, Jack L., Patrick Regan, and William W. Priest, Jr. 1976. *The Financial Reality of Pension Funding under ERISA.* Homewood, IL: Dow Jones-Irwin.

Waring, M. Barton. 2004. Liability-Relative Investing II. *Journal of Portfolio Management*, Fall.