Pension Policy and Benchmark Optimization*

A new approach succeeds at integrating optimal asset allocation with economic pension liabilities.

by Richard O. Michaud

As a practical matter, pension plan sponsors must relate an understanding of their pension liabilities and the prospective risk/return characteristics of capital market instruments to the specific problem of determining an optimal asset mix. Although a number of approaches have been proposed to resolve this problem, most have fallen short of producing an integrated economic framework.

We will present a new approach to establishing an optimal investment policy for defined benefit pension plans, called "benchmark optimization." A unique feature of this approach is that it provides a framework for integrating the economic characteristics of pension liabilities with capital market expectations in a financially meaningful way. What emerges is a deeper understanding of the respective roles of equity and fixed income instruments that is consistent with much institutional practice.

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Policy versus strategy

A pension plan's asset allocation policy is, by far, the sponsor's single most important investment decision. Studies have shown that roughly 94% of the variance of the performance of the plan's assets is determined by the long term *average* asset allocation.[1] The remainder of the variance can be ascribed in roughly equal measure to active asset allocation and security selection.

These findings highlight the importance of distinguishing between investment policy and investment strategy. Policy is concerned with the normal or long run average asset mix. Strategy is concerned with short term considerations that are useful in enhancing return.

[1] Brinson, G. and J. Diermeier, 1985, "The Multiple Asset Investment Setting." Presented to: *The Institute for Quantitative Research in Finance*, Spring.

Again, policy is validly concerned with such issues as the firm's strategic objectives, the economic characteristics of the plan's liabilities, the plan's funding level and the long term risk and return available from financial assets. In contrast, strategy is primarily concerned with current expectations of the global market environment and its implications for enhancing return. While this article will focus narrowly on plan policy issues, the methodology can also be used to implement strategy.[2]

Mean-variance efficient asset mixes

One approach to defining an optimal asset mix is mean-variance (MV) efficient frontier analysis.[3] In this procedure, expected returns, variances and correlations are estimated for all the asset classes under consideration. Portfolio optimization allows the computation of asset allocations that maximize expected return at a given risk level for the given inputs. The set of all optimal asset mixes defines an "efficient frontier" and represents an efficient use of the information in the forecasts.

Exhibit I provides the results of a traditional MV efficient frontier analysis for three asset classes[4] — U.S. stocks, long term corporate bonds and T-bills — based on annual return data over the twenty-five year period, 1963-87.[5] The results are stated in terms of the efficient frontier "pivot" portfolios, from

Exhibit I

Traditional Optimization, 1964-1987
Mean-Variance Efficient Pivot Portfolio (%)

Pivot Portfolios*	T-Bills	Bonds	Stocks
1	95	0	5
2	0	0	100

*Results slightly simplified

[2]A study to implement strategy will differ significantly in focus and procedures from one oriented to defining policy.

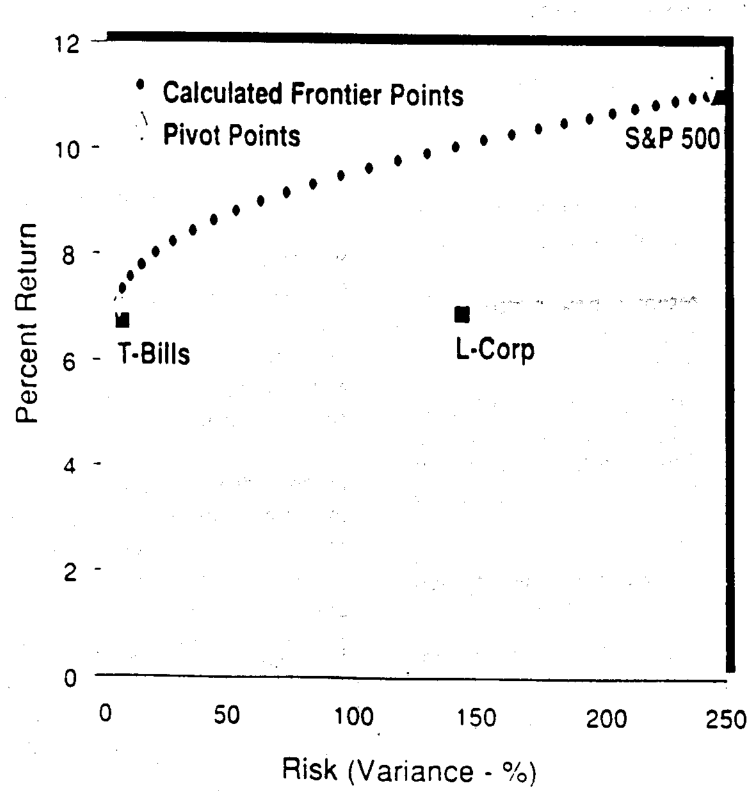
[3]Markowitz, H., 1959, *Portfolio Selection: Efficient Diversification of Investments*, John Wiley, NY.

[4]It should be stressed that this example, and others in the report, are of value to illustrate generic investment policy issues, and are not examples of a comprehensive asset allocation study.

[5]Data from Ibbotson Associates, Inc., Chicago, IL 60678.

Exhibit II

Traditional Optimization, 1963-1987



lowest to highest variance.[6] The efficient frontier is shown in Exhibit II: efficient portfolios are plotted between the pivot portfolios to fill in the curve.

The results show that, for this time period, the efficient asset mixes consist of T-Bills and equities; bonds are not part of the efficient asset mixes. The minimum risk efficient asset mix is primarily T-Bills; at high risk levels equities dominate. We note that these results are time period dependent: other time periods may, and often do, lead to very different optimal asset mixes.

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Mean-variance: pros and cons

MV efficiency analysis is the foundation of modern portfolio theory and much of modern finance.[7] It is intuitively appealing in the sense of making best use of available information. It is also a flexible tool in that many asset classes of interest can be included in the analysis.

But MV analysis has a number of significant limitations. Probably the most important is its inherent single-period nature: that is, longer horizons may lead to different conclusions. Considerable care must be used to extrapolate asset mix recommendations in light of the long term objectives typical of pension funds.[8]

Formally, estimates of an asset's mean, standard deviation and pairwise correlations are all that is required to include that asset in an optimization. However, the mean-variance assumptions implicit in efficient frontier analysis have to be satisfied in order for the results to have financial meaning.

The assumptions are satisfied if the return distribution of each asset class is well approximated by a normal distribution. Such considerations rule out using options and option based strategies.

While fixed income and real estate assets are often included in MV efficient frontier analysis, interpreting the results can be problematic since their historical return distributions do not strongly satisfy the mean-variance assumption.

The MV optimization process itself is subject to a number of serious limitations.[9] One important example is that MV efficient portfolios are not unique. The estimates input to an efficient frontier analysis are subject to estimation error.[10] Consequently, for any given optimal portfolio there are many other portfolios that are equally optimal at the same risk level but may have very different financial structures.[11]

The financial consequences of the non-uniqueness problem are well known, if not well understood, by many practitioners. Non-uniqueness often shows up as input estimate sensitivity. Even small changes in the inputs can lead to large changes in the optimal asset mix. The larger the number of assets, the more input sensitive the results. This raises fundamentally important questions concerning the financial meaning of efficient frontier optimality.

Benchmark optimization

An important technique for dealing with a number of problems associated with MV efficiency analysis, including its sensitivity to the input assumptions, is to use a benchmark as part of the MV optimization. In this procedure, the input assumptions are redefined to represent residual returns with respect to the benchmark. Consequently, benchmark risk is fully integrated into the optimization process.

Curiously, while optimization with respect to a benchmark is well established for equity portfolio optimization, it is not for asset allocation. For pension fund management, an optimal asset mix is most appropriately defined in terms of funding the plan's economic liabilities. Optimal asset allocation based on the total risk/return characteristics of the "surplus," or assets minus liabilities, is a natural way to extend MV optimization.

[6] A "pivot" portfolio is a point on the efficient frontier where an asset(s) drops out of or enters the optimal solution. All optimal asset mixes on the efficient frontier are (convex) linear combinations of the pivot portfolios. In some cases the actual computed results have been slightly altered for explanatory purposes.

[7] Markowitz, op. cit.

[8] Michaud, R. 1981, "Risk Policy and Long Term Return," *Journal of Financial and Quantitative Analysis*, June.

[9] For further discussion see: Michaud, R. "The Markowitz Optimization Enigma: Is Optimized Optimal?" *Financial Analysts Journal*, Jan/Feb 1989a.

[10] Since estimates of the parameters are not known with certainty in problems of practical interest, they are said to be subject to "estimation error."

[11] For a more detailed discussion see: Michaud, 1989a, op. cit.

Duration versus total risk

At least since the late 1950s,[12] *total* return and *total* risk have been the return and risk measures of choice for asset allocation studies. It is therefore difficult to understand why some authors have recently focused on duration as a risk measure.

Duration is a measure of interest rate sensitivity. It is primarily useful in the fixed income area for security valuation and portfolio management. For equities, however, duration is theoretically an incomplete measure of risk that often has little explanatory power.

Our illustrations of benchmark optimization ignore duration issues by design and are based exclusively on total risk. The end result is less theoretically suspect, conceptually simpler, and more likely to have valid investment meaning.

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Exhibit III

Benchmark Optimization, 1963-1987
Termination Liability
Mean-Variance Efficient Pivot Portfolios (%)

Pivot Portfolios	T-Bills	Bonds	Stocks
1	0	100	0
2	0	0	100

A simple example

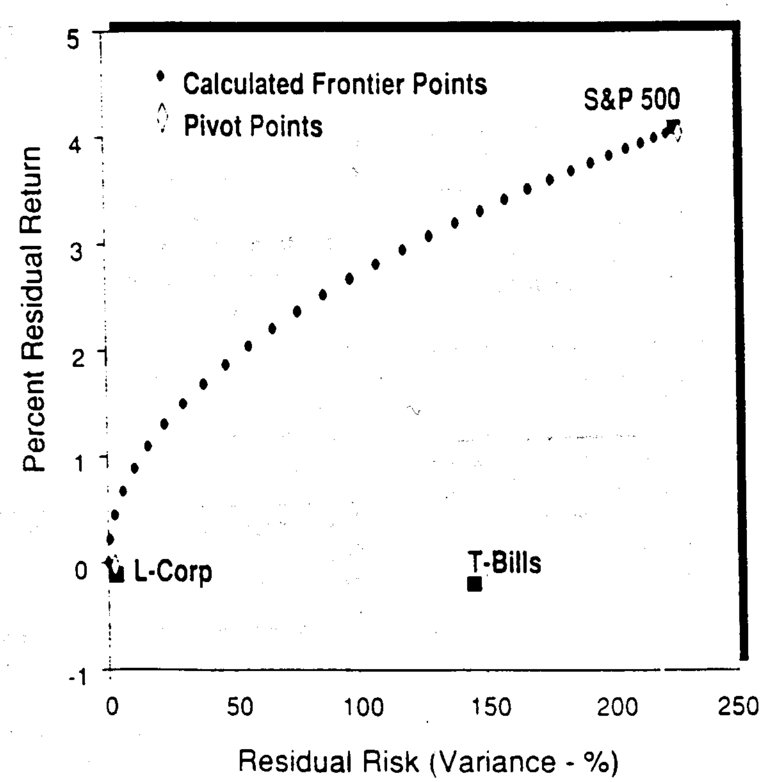
Assume that an important component of a pension plan's liability is the termination liability[13] associated with active, inactive and retired employees and that the plan is fully funded in this regard. Such obligations are associated with minimum funding levels and are similar to long term fixed income instruments. They have long maturities and highly predictable cash flows that are fixed in nominal dollars

[12] Markowitz, op. cit.

[13] Termination liability is similar to, but not identical with the FASB 87 accrued benefit obligation (ABO) liability.

Exhibit IV

Benchmark Optimization, 1963-1987



over a given period. The primary risk factor is interest rate risk. A simple but useful model for the changes in liability values is long term corporate bond total returns, which will be used as the benchmark. Exhibits III and IV illustrate the results of benchmark efficient frontier analysis. The results are in the same format and also based on the same data used earlier.

As can be observed, benchmark optimization may produce significantly different conclusions from traditional analyses. In this case, every stock/bond mix is optimal. The results are nearly time period independent; the optimization is largely driven by the definition of the benchmark.

The role of bonds and equities in efficient asset allocation policy emerges. Bonds, not T-Bills, minimize termination liability funding risk, which is consistent with earlier studies in surplus management that used duration as the measure of risk.[14] While bonds minimize risk, equities efficiently enhance return. Without a statement of risk preferences, stocks and bonds are equally efficient.

"Without a statement of risk preferences, stocks and bonds are equally efficient."

The results rationalize significant commitments to equities by many pension plan sponsors even when solely concerned with funding current liabilities. Exclusively minimizing risk implies opportunity costs — in terms of the likelihood of foregone superior long term performance — that may have important plan funding consequences.[15]

Exhibit V

Benchmark Optimization and Funding Level
Mean-Variance Efficient Pivot Portfolio (%)

Pivot Portfolios*	T-Bills	Bonds	Stocks
1	48	50	2
2	0	0	100

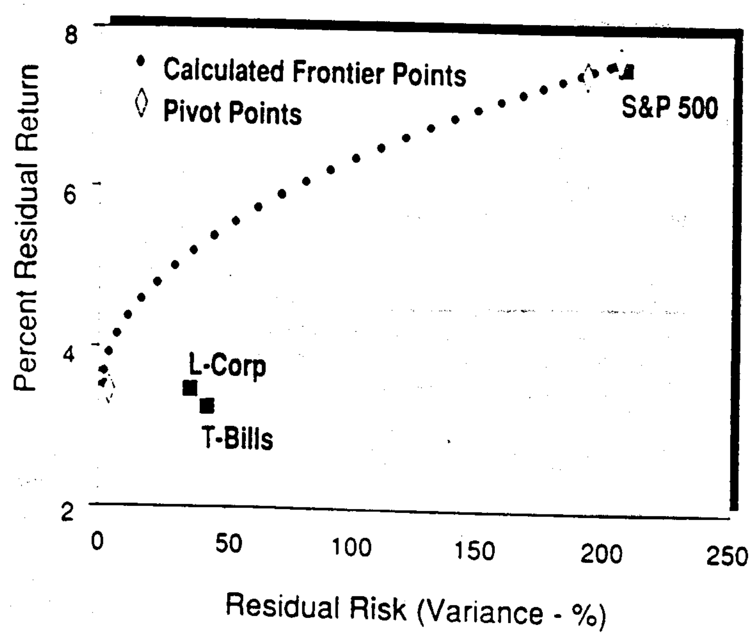
*Results simplified

[14]Of course, this result depends on an implicit duration match between the liabilities and the long term bond portfolio. The point is that duration may have a prominent place in designing an appropriate fixed income portfolio but it should not generally be the sole basis for the asset allocation decision.

[15]This example, and its conclusions, are directly applicable to the problem of optimal asset allocation policy for defined contribution pension plans.

Exhibit VI

Benchmark Optimization and Funding Level, 1963-1987



Why benchmark optimization is different

Recommendations derived from asset allocation studies are often based almost exclusively on capital market expectations. Pension liabilities, when included in the process, are often treated as fixed value funding targets, possibly adjusted for a variable inflation rate.[16] Economic pension liabilities, however, are stochastic and fundamentally linked to financial markets and the economy. This is true not only in the discounting process (which includes inflation as one component) but also in the expected cash flows over time.

It is this critically important stochastic economic linkage between assets and liabilities that is missing in other approaches to asset allocation. This difference and the fact that the total risk, not duration, of the economic surplus is used to measure risk, distinguishes benchmark asset allocation.[17] As a consequence, benchmark asset allocation studies, properly designed, will often lead to substantially different asset mix recommendations.

Funding level and the optimal asset mix

The optimal asset mix depends on the funding level of the plan. Yet this fundamentally important consideration has generally been ignored in asset allocation studies. For example, the results in Exhibit III are valid only if the plan is fully funded with respect to termination liabilities.

To illustrate the funding level impact, assume that the plan is overfunded in the sense that the termination liabilities are half the value of the assets. The results are given in Exhibit V and VI; the format and data are those used earlier.

These results show that funding level is a first order effect. Efficient asset mixes are roughly equal portions in T-Bills and bonds, the rest in equities.

"It is this critically important linkage between assets and liabilities that is missing in other approaches."

The minimum risk asset mix is not 100% bonds. Bonds play the same role as in the previous example but the overall allocation is altered to reflect the assumed size of invested assets. The remainder of the assets enter the optimization in the more traditional role of efficiently maximizing return and decreasing risk. These results also reinforce the fundamental role of equities as a means of enhancing return.

Conclusions

Benchmark optimization, properly performed, represents a powerful new approach for defining an appropriate pension fund asset allocation policy. A unique feature of this approach is the ability to develop optimal asset mix recommendations in an integrated framework that includes capital market expectations, funding status and stochastic economic linkage between assets and liabilities.

Many important policy issues remain to be developed. These include more specific applications and detailed modeling of the economic characteristics of the pension liabilities, as well as consideration of alternative asset classes and strategic objectives.

While the examples given were necessarily limited in scope, some important generic investment principles, consistent with much institutional practice, emerged. In particular, benchmark optimization highlights the role of bonds for minimizing surplus risk and showed that, even in the case of funding fixed cash flow liabilities, equities have a major role in efficient asset allocation. In the context of more comprehensive definitions of plan liabilities, the role of equities, and other assets, is likely to increase.

Finally, it should be noted that benchmark optimization technology is applicable to a wide range of policy and strategy asset allocation problems, including those of insurance companies, endowment funds, foundations and individuals.

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[16] An example of a traditional asset allocation study that features extensive modeling of pension liabilities is: Michaud, R., "Pension Fund Financial Planning," presented to: *The Institute for Quantitative Research*, May 1976.

[17] For further discussion see: Michaud, R., "Economic Surplus and Pension Asset Management," *Pension Executive Review*, Merrill Lynch, January 1989b.