Enterprise Risk and Return Management for Financial Institutions

Mark Griffin* and Rick Boomgaardt†

Abstract

It is important to include both risk and return in finding the optimal balance of assets and liabilities for financial institutions. Insurance companies, with their range of sophisticated assets and liabilities, are perhaps the best example of the value of such an approach. Examples in the paper refer to the insurance industry, but parallels to other types of financial institutions are easily drawn. The analysis in the paper shows that a comprehensive approach to risk and return produces some interesting conclusions with respect to asset allocation, active versus passive asset management, and the mix and pricing of liabilities.

Introduction

On the topic of integrated approaches to risk measurement in the financial services industry, it must be remembered that rational investors and market participants take risks in pursuit of returns. While it is noble to study and measure risk in isolation, it is dangerous to do so without remembering the motivation for accepting risk.

Imagine for a moment that we are successful in determining one measure of risk that can be applied broadly to the financial services industry. Such a measurement would be a wonderful regulatory yardstick, but by itself would not be very useful in managing the business. We would soon realize that there are many ways to get to any particular risk level (except maybe zero risk). Taking too little risk may be a substantial longer-term danger if adequate return cannot be earned. In a healthy enterprise, management must be responsible for both risk and return.

As a result, an efficient frontier approach to risk and return management is proposed and outlined in this paper. The standard deviation of the portfolio of assets, liabilities, and surplus is the underlying risk measurement tool. The imposition of stress tests on the institution will produce constraints that can be incorporated into the asset and liability optimization. This paper will demonstrate how this approach can be used for the most general case: comprising a mixed portfolio of assets, a mixed portfolio of liabilities, active as well as passive asset management, and the inclusion of surplus. The techniques involved are not new, are intellectually widely accessible, and can be easily run using common spreadsheet packages.

The Asset Portfolio Dimension

To begin, imagine that our institution has a set of certain liability cash flows that happen (conveniently) to mimic the ten-year Government bond. (In practice, a portfolio of bonds can be constructed to mimic a portfolio of certain cash flows, but we will assume for simplicity that the liabilities match the ten-year bond.)

An asset portfolio consisting entirely of ten-year bonds with no credit risk represents a riskless portfolio in this situation. Therefore, we refer to the ten-year bond as the liability benchmark. As a result, the risk of any portfolio is measured as its risk relative to the ten-year bond. This risk of one asset portfolio relative to another is known to portfolio managers as tracking error. As a historic standard deviation measurement, it must be classified as a value-at-risk type of approach. As such, it incorporates both the probability and severity of changes. In contrast, duration is a measure of the severity of a particular event, with no recognition of its probability. In our situation, an

*Mark Griffin, F.S.A., C.F.A., is Vice President of Goldman Sachs and Company, 85 Broad Street, New York, NY 10004, e-mail, mark.griffin@gs.com.

†Rick Boomgaardt is an Analyst at Goldman Sachs International, Peterborough Court, 133 Fleet Street, London EC4 A2BB, UK, e-mail, rick.boomgaardt@gs.com.

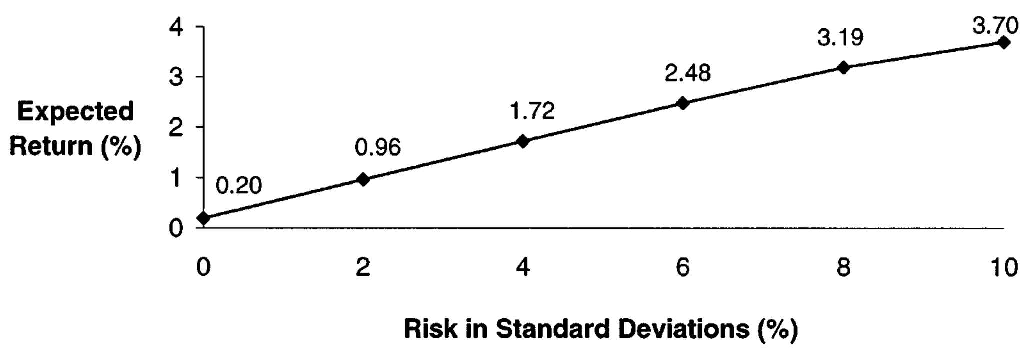
asset portfolio consisting exclusively of seven-year bonds will have a lower tracking error (1.93%) than a portfolio of cash (6.89%). The liability perspective is clearly crucial because, if we just measured the historical volatilities of the seven-year portfolio and the cash portfolio, the seven-year portfolio would appear to be the riskiest.

Let us also assume that we are able to "sell" this product (and therefore create a liability) at 0.20% below the ten-year yield, after adding in expenses. One might quickly conclude that this is an attractive business (although this is hard to judge without knowing the capital requirement). This situation is depicted in Figure 1. Below the risk points on the horizontal axis is shown the asset portfolio that produces the highest expected return for that level of risk. In each case risk is measured as the historic risk of the portfolio relative to the liability benchmark. Hence, the zero risk portfolio consists entirely of the ten-year bond. The line shown is the efficient frontier, and varies from classical efficient frontier analysis only in its recognition of risk as being measured relative to liabilities.

Beside each asset class is shown its expected return for this analysis. The expected returns for cash and bonds are set equal to their current yield at the time of analysis. The equity expected return premium is set, arbitrarily, at 3.5% over ten-year bonds. International equity expected returns are set equal to domestic equity expected returns. Expected returns for international bonds are equal to like-duration domestic bonds. Research by Jorion (1985) demonstrates that while returns can be very different over different periods, volatilities and correlations are reasonably stable. This supports the use of expected returns with historical volatilities and correlations. Equal expected returns for international and domestic are also used by Jorion (1989). The approach demonstrated in this paper can be used for any set of expected returns, volatilities, and correlations. Table 1 shows the covariance matrix used.

Although the examples in the paper refer to the insurance industry, the parallels to other financial institutions are easily drawn. Ignoring for a moment the 0.20% gap between the expected return or "cost" of

Figure 1
Efficient Frontier Relative to Certain Ten-Year Liability



Asset Allocation	Expected Return	Optimal Portfolio Composition					
Cash	5.0%	0%	0%	0%	0%	0%	0%
3 yr bonds[a]	6.0	0	0	0	0	0	0
10 yr bonds	6.5	100	65.7	31.5	0	0	0
30 yr bonds	6.8	0	13.8	27.5	38.2	16.0	0
Int'l bonds	6.3	0	0	0	0	0	0
US equity	10.0	0	17.4	34.8	52.5	72.8	89.4
Int'l equity	10.0	0	3.1	6.2	9.2	11.2	10.6
		100%	100%	100%	100%	100%	100%

(a) Bonds refer to government bonds.

Table 1
Covariance Matrix
(Based on Monthly Data December 1985–December 1996)

	3 Year	10 Year	30 Year	Cash	Equity	International Equity UH	International Bonds
3 Year	0.752791	1.606454	2.136163	0.016969	1.233631	0.914196	0.901976
10 Year		3.9657433	5.548046	0.02019	3.541631	1.928303	1.860078
30 Year			8.258902	0.023019	5.131891	2.712368	2.440409
Cash				0.028468	0.026892	−0.04136	−0.02082
Equity					11.01535	6.710671	1.41571
International Equity						23.72586	4.678157
International Bonds							2.772371

the liability relative to the matching asset, our example also represents a securities broker who has "sold" (that is, committed to deliver) the ten-year bond. The broker can match the position by buying an offsetting "long" position in the same ten-year bond. Alternatively, in the course of market making activities, the broker might be long some other set of securities instead of the ten-year bond. Again, the relevant risk measure is the risk of the "long" portfolio relative to the "short" portfolio. Obviously, the seven-year bond is not a perfect hedge for the ten-year exposure, but it is a better hedge than just having cash exposure (which in market terms is the same as having no exposure).

As we move from left to right in Figure 1, more risk is taken relative to the liability benchmark through shifting into asset classes with higher expected returns.[1] The composition of the asset portfolios is obviously dependent on the expected return we assign to different asset classes. It is interesting to note that, when international bonds are assigned the same expected return as equal duration domestic bonds, they are never chosen. Relative to domestic bonds they offer only increased risk, and not increased return. Currency hedging international bonds removes a considerable amount, but not all, of the marginal risk. Absent the liability benchmark approach, when risk is measured with respect to assets only, international bonds typically get an allocation due to their diversification qualities.

Figure 1 also shows that for this set of assumptions, the most efficient way to add risk is to move not only into equities but also into longer bonds. Again, it is the risk of the 30-year bond relative to the ten-year bond which is relevant.

It is also interesting to see how the equity portfolios in Figure 1 are very concentrated in domestic equities. This is a consequence of the significant positive correlation, 53.6%, between domestic equities and domestic bonds. International equities tend to have a lower correlation, 20%, to domestic bonds (that is, the liabilities).[2] Therefore, absent an expected return motivation for holding international equities, the equity portfolio has a higher domestic concentration than if the liability perspective is not taken.[3]

Based on this analysis, our institution would choose its strategic asset allocation as the point on the efficient frontier corresponding to its maximum risk tolerance.

STRESS TESTING

It may be necessary for the institution to demonstrate that it can remain solvent in a number of prescribed financial market scenarios. If we treat surplus and liabilities as a given, the effect of a stress test may be incorporated into the optimization process as a series of constraints on the assets. As an example, suppose that we were required to show that current surplus can withstand a drop in interest rates of 3%. This

[1]The proportionate allocation to international and domestic equity in Figure 1 (over the 0–4% range of overall risk, at which some of the riskless asset is held) demonstrates that the Separation Theorem, first uncovered by Tobin (1958), applies also when risk is measured against benchmarks other than cash. Tobin observed that "The convenient fact that has just been proved is that the proportionate composition of the non-cash [i.e., risky] assets is independent of their aggregate share of the investment balance."

[2]In the optimization, both currency hedged and unhedged international equities are included in the universe. Only unhedged international equities are chosen in the optimal portfolios. This result is consistent with other research, as in Jorion (1989) and Nesbitt (1991), showing that for small international allocations, the optimal currency hedging ratio is close to or equal to zero.

[3]Many of the asset allocation phenomena shown in Figure 1 are addressed in more detail in Griffin (1997).

could be done by setting a constraint within our optimization that the duration mismatch between assets and liabilities could be not more than a certain amount based on our surplus level. As a further sophistication that could incorporate convexity and the presence of options, each asset class could be assigned a specific sensitivity to a drop in interest rates of 3%, and a constraint formulated in terms of the net effect on assets and liabilities. It is easy to see how overall risk-based capital constraints, such as those that apply to insurers and banks, could be formulated based on the application of different percentages to different asset types. The expected impact of both types of constraints would be to flatten or nullify the efficient frontier beyond a particular risk level. In many cases, the combination of existing capital levels and capital constraints based on asset type may shorten the efficient frontiers of financial institutions from the economic efficient frontier shown in Figure 1.

Apart from complying with external, arbitrarily set constraints, stress testing can be useful in measuring and thereby managing risk. The phenomenon of ''fat tails'' is familiar to those modeling options portfolios. For example, to determine the size of a particular risk, one could stress test based on a move of a prescribed number of standard deviations with respect to that variable. To find the relative order of magnitude of other risks, the same process could be repeated using a shock of the same number of standard deviations. This way, the probability of the tested event could be estimated, and a fair basis of comparison between different risks would be possible.

ACTIVE VERSUS PASSIVE ASSET MANAGEMENT

As actuaries, we tend to feel that the financial services business has enough risk without adding additional risk through active asset management. However, the comprehensive efficient frontier framework proves very convenient for putting active asset management risk in perspective.

Our example uses the historical time series of benchmark government bonds, and ''market'' equity indices. Risk calculations therefore assume that those indices will be followed passively in the various portfolios.

Let us assume that the portfolio in Figure 1 corresponding to a risk of 4% is the strategic asset allocation that has been chosen. Suppose that within the domestic equity portfolio, which comprises 34.8% of the portfolio, our holdings do not match the index but overweight and underweight different stocks within the index, and also include some stocks not represented in the index. The tracking error or historical standard deviation of our domestic equity portfolio relative to the domestic equity index is 3%. (Commercial software packages are available to do this calculation and are widely used by active equity portfolio managers to measure their tracking error relative to an index.) To measure the additional risk of active management, it is important to know if our overall market exposure, or beta, has changed through our selection of stocks. For example, if we overweighted cyclical stocks relative to the index, our beta would be increased beyond one as we would expect to outperform the market in positive parts of the ''cycle'' and underperform the market in negative parts of the cycle. In measuring risk, our actual beta would be applied to our allocation to equities. For example, if our beta is 1.05, our exposure to the domestic equity market would be 5% higher than our allocation.

If we assume that we haven't taken additional market exposure through our active equity selections, that is, we still have a beta of one, the overall tracking error can be recalculated as follows:

$$\text{StdDev}\ (X + Y) = sqrt[\text{var}(X) + \text{var}(Y) + 2\text{cov}(XY)]$$

where:

var(X) = risk relative to liability benchmark based on an investment in the relevant indices in accordance with the strategic asset allocation (in this case 4%)

var(Y) = additional tracking error taken within the equity portfolio through active management (in this case 34.8% of 3%, which is 1.04%)

Because X and Y are uncorrelated, the covariance term is zero, and the calculation is reduced to the following:

$$\text{StdDev}\ (X + Y) = sqrt[(4 \times 4) + (1.04 \times 1.04)] = 4.13\%$$

The calculation shows that overall tracking error is increased by 0.13% through active equity management. Using the slope of the efficient frontier (0.38 at the point of the strategic asset allocation), we should require 0.05% of additional expected return on the portfolio (equivalent to 0.14% on the domestic equity portfolio) to justify the extra risk of active equity portfolio management. We use the slope of the efficient frontier because, if we cannot expect to earn an additional 0.05% from active management, then we are better off to simply adopt a more risky strategic asset allocation and capture the resultant increase in expected return than we are to adopt active management.[4]

It should be noted that due to the calculation of the incremental portfolio risk, the relationship between tracking error and required added return favors low levels of tracking error. For domestic equity portfolio tracking error of 1%, an additional 0.02% must be earned on the domestic equity portfolio for active management to be worthwhile. For 3% tracking error, additional required return is 0.14% (as shown), and for 5% tracking error the additional return is 0.40%. It is very intuitive that active management should add return to be worthwhile. The value of the comprehensive approach is to enumerate how much additional return is required as a function of incremental risk.

This approach should provide some rules of thumb for active stock selection. Also, if there are additional passive stock indices that may be relevant, they should be part of the optimization procedure. If the strategy under consideration has quantifiable historical returns based on sector returns, timing, and so on, it should also be included explicitly in the optimization. This way, the optimal composition and overall size of the equity portfolio can be determined.

The comprehensive approach can be used for a number of relative risk and reward decisions. As another example, suppose that because of what was viewed as a temporary yield curve shape phenomenon, we felt that a duration-weighted barbell of the three-year bond and the thirty-year bond would outperform the ten-year bond by 0.20%. Moving 20% of the overall portfolio allocation out of ten-year bonds and into a duration matching combination of three- and 30-year bonds increases portfolio tracking error by only 0.02%. In this situation, implementing the bond barbell strategy would be a better portfolio risk versus return tradeoff than simply adopting a more aggressive strategic asset allocation (the ratio of incremental portfolio return to incremental risk is 2.0, far greater than the slope of the efficient frontier). In practice, an asset manager's incremental return over the identified benchmark divided by the tracking error incurred relative to the benchmark is known as the information ratio.

THE LIABILITY DIMENSION

Our example is hardly a general case if we have only one type of liability that is certain in nature. Let us add a second, more interesting type of liability. In this case the expected cash flows are shorter and (again conveniently) mirror the three-year bond. This liability can be "sold" (including expenses) at 1.0% below the three year. However, in this case there is an additional degree of uncertainty to the cash flows as a result of insurance underwriting uncertainty. This random element has a standard deviation of 6%, and does not change the expected return or "cost" of the second liability.[5] (For convenience, we will refer to the liabilities as A and B, in the order they were introduced.)

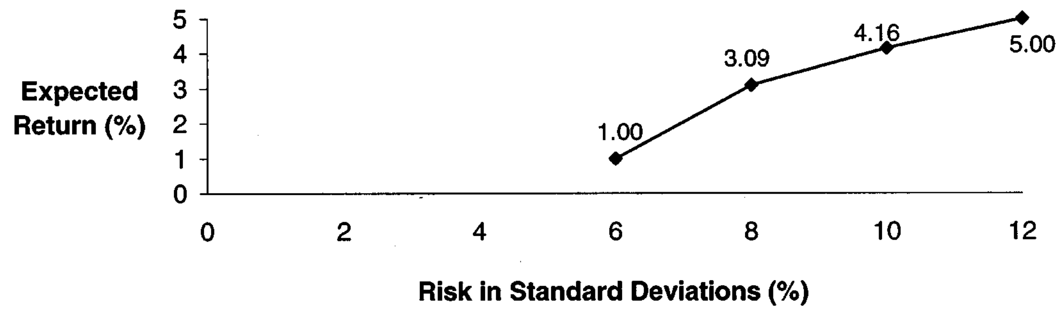
First we will consider Liability B by itself. Figure 2 shows the efficient frontier analysis on this basis. In contrast to Liability A in Figure 1, it is impossible to have zero risk because Liability B cannot be matched by an asset. Risk can be minimized at 6% by holding the asset, the three-year bond, which matches the expected cash flows of Liability B. At this point the excess expected return of assets over liabilities is clearly 1.0%. As we move to higher levels of tracking error, the efficient frontier consists of more aggressive asset portfolios with higher expected returns.

Liability B is designed to represent some of the characteristics of the property & casualty (P&C) insurance business. While life insurance liabilities have some risk, it would be generally appropriate to think of Liability A as representing life insurance. Because Liability B cannot be matched explicitly by an asset, the marginal reward for taking additional risk is greater than for Liability A. (The slope of the efficient frontier in Figure 2 between 6% tracking error and 8% tracking error is 1.04; the slope in Figure 1 is 0.38.) Hence, it appears P&C insurers should use riskier assets than life insurers because their liabilities are riskier. Because assets and P&C liabilities are imperfectly correlated, the overall net effect is to lessen the impact of incremental asset risk. This effect is similar to the small marginal increase in portfolio risk as a result of active management shown earlier in the paper. This result seems consistent with the practice of P&C insurers to invest more in equities than life insurance companies (surplus issues are discussed later in the paper). However, Figure 2 does not show the tendency of P&C insurers to extend their bond holdings along the yield curve beyond the duration of their liability

[4]This concept is also addressed in Liebowitz (1995).

[5]In our example the random element of the liability is assumed to be uncorrelated to all asset classes. This topic is discussed in Parker (1997).

Figure 2
Efficient Frontier Relative to Uncertain Three-Year Liability



Asset Allocation	Expected Return	Optimal Portfolio Composition			
Cash	5.0%	0%	0%	0%	0%
3 yr bonds[(a)]	6.0	100	47.8	21.1	0
10 yr bonds	6.5	0	0	0	0
30 yr bonds	6.8	0	0	0	0
Int'l bonds	6.3	0	0	0	0
US equity	10.0	0	42.5	64.2	85.2
Int'l equity	10.0	0	9.8	14.8	14.8
		100%	100%	100%	100%

(a) Bonds refer to government bonds.

cash flows. A slight increase in the expected return of the ten-year bond to 6.6% from 6.5%, while leaving all other expected returns unchanged, is all that it takes to begin to draw an allocation from the three-year to the ten-year. This indicates that, depending on one's assumptions, it is reasonable for P&C insurers to take risk not just by allocating to equities, but also by extending beyond the liabilities on the yield curve.

It is also interesting that the domestic versus international split of the equity holdings is different for Liability B than for Liability A. Liability B is shorter duration than Liability A and has additional volatility, which makes it less bond-like. Therefore the strong correlation between domestic bond returns and domestic equity returns is less of a factor than in Figure 1, and as a result the proportion of overall equities allocated to domestic is lower in Figure 2 than Figure 1.

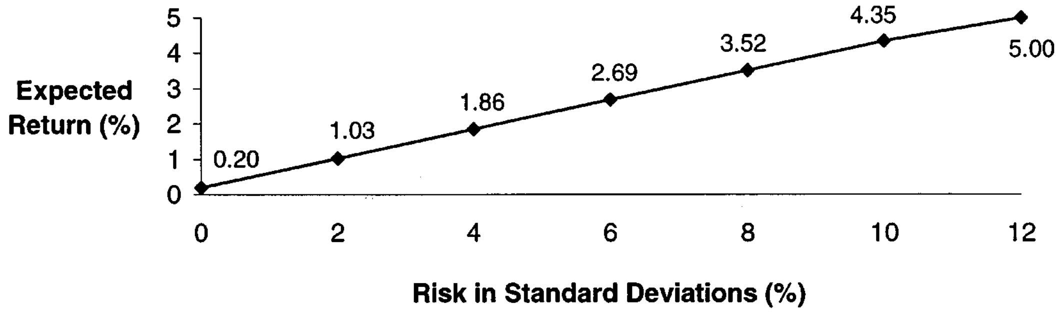
The next step is to allow the optimization process to choose simultaneously between the two liabilities, and between the various asset classes. This is shown in Figure 3. Figure 3 lists the composition of the liabilities at each risk level below the asset portfolio breakdown.

Figure 3 demonstrates the virtues of liability diversification. Consider an insurance company writing only Liability A with a tolerance for tracking error of 6%. If Liability B is then considered on a stand-alone basis, it would appear very unattractive. If the enterprise could tolerate tracking error of 6%, it would be better off choosing Liability A, and the corresponding optimal asset allocation, which offers an expected return of 2.48%. However, on an enterprise basis, there is clearly benefit to writing some of each liability. Even if the company's tolerance for overall tracking error were lower than 6%, an allocation to Liability B would give the enterprise more expected return than writing Liability A exclusively. This example shows the management benefits of looking at risks and returns holistically rather than individually.

Actuaries will notice that these findings have implications in product pricing. The results demonstrate that using a single profitability hurdle rate for a particular product may be overly simplistic and give suboptimal results. The entire portfolio of assets and liabilities is relevant in making a pricing decision.

With this simple example in place, it is easy to test some sensitivities. For example, we can change the

Figure 3
Efficient Frontier with Respect to Assets and Liabilities



Asset Allocation	Expected Return	Optimal Portfolio Composition						
Cash	5.0%	0%	0%	0%	0%	0%	0%	0%
3 yr bonds[a]	6.0	0	0	0	0	0	0	0
10 yr bonds	6.5	100	79.8	59.6	39.4	19.2	0	0
30 yr bonds	6.8	0	1.2	2.5	3.7	4.9	5.1	0
Int'l bonds	6.3	0	0	0	0	0	0	0
US equity	10.0	0	15.8	31.6	47.3	63.1	78.9	84.0
Int'l equity	10.0	0	3.2	6.4	9.6	12.8	16.0	16.0
		100%	100%	100%	100%	100%	100%	100%

Liability Allocation	Expected Return	Optimal Portfolio Composition						
A	6.3%	100%	87.6%	75.1%	62.7%	50.2%	37.5%	0%
B	5.0	0	12.4	24.9	37.3	49.8	62.5	100

(a) Bonds refer to government bonds.

pricing of the liabilities so that both are more profitable by the same amount. Rerunning Figure 3 on these assumptions increases expected returns at all risk levels uniformly but does not change the allocations to assets or liabilities at all.

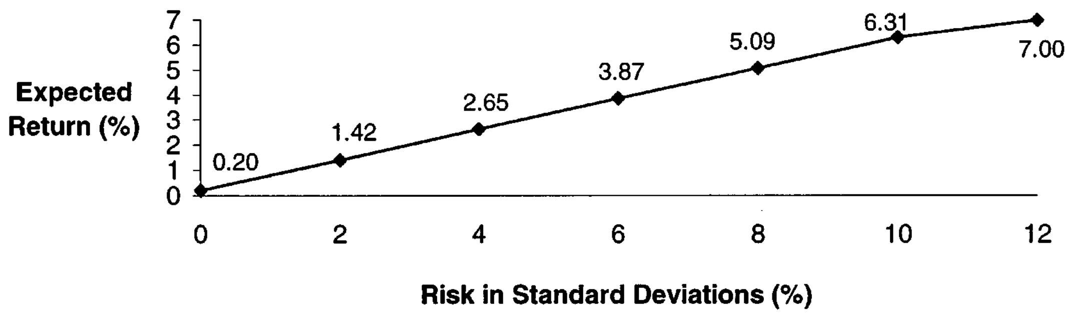
Figure 4 shows the optimal asset and liability allocations when the expected returns on equities are increased by 2% from the original levels. Comparing Figure 4 to Figure 3 shows some intuitive results as well as some non-intuitive results. Comparing efficient portfolios at the same risk level, less risk is taken on the liabilities and more on the assets in Figure 4. What is perhaps surprising is that there is a larger change in the liability distribution than there is in the asset allocation.

Changing the risk relationship between the liabilities also changes the optimal allocation of both assets and liabilities.

A potential application of this approach is the combination of liabilities in different countries to demonstrate the risk reduction of international diversification of businesses.

It is also possible to incorporate marginal expenses into the analysis. The spread at which various liabilities can be "sold" can be made dependent on the size of their allocation in order to recognize economies of scale. It is probably not realistic to assume that the liability profile can be changed completely in the push of a button. This can be handled by putting constraints on the allocations to the liabilities based on reasonable limits over the management planning horizon. It may be useful to widen these liability size constraints beyond their short-term limits to demonstrate the mix of business that would be desirable over a longer horizon.

Figure 4
Efficient Frontier with Increased Equity Expected Returns



Asset Allocation	Expected Return	Optimal Portfolio Composition						
Cash	5.0%	0%	0%	0%	0%	0%	0%	0%
3 yr bonds[a]	6.0	0	0	0	0	0	0	0
10 yr bonds	6.5	100	79.81	57.4	36.1	14.8	0	0
30 yr bonds	6.8	0	0.8	2.4	3.6	4.8	0	0
Int'l bonds	6.3	0	0	0	0	0	0	0
US equity	12.0	0	17.0	34.0	51.0	68.0	84.5	84.5
Int'l equity	12.0	0	3.1	6.2	9.3	12.5	15.5	15.5
		100%	100%	100%	100%	100%	100%	100%

Asset Allocation	Expected Return	Optimal Portfolio Composition						
A	6.3%	100%	91.2%	82.6%	73.9%	65.2%	53.0%	0%
B	5.0	0	8.8	17.4	26.13	34.8	47.0	100

(a) Bonds refer to government bonds.

The role of corporate bonds is both beyond the scope of this paper and hampered by lack of applicable data. Relative to government bonds, corporate bonds offer an incremental return (spread on bonds minus expected default losses) but have incremental risk due to spread changes and defaults. The incremental risk cannot be treated as simply as active management tracking error was earlier, as it is very dependent on the economic cycle. Building a large diversified portfolio of corporate bonds can only mitigate this cyclicality to a limited degree. The holistic approach is well suited to evaluating the optimal proportion of the portfolio to be in corporate bonds by measuring their incremental risk and return relative to liabilities alongside the incremental risk and return of other instruments, while incorporating the diversification benefits of all categories of assets and liabilities.

INCORPORATING SURPLUS

Financial institutions hold surplus as a buffer against risks. Comparison of the surplus level to the overall risk level allows one to estimate the probability of ruin. For example, a 6% overall risk level and a surplus of 12% of assets translates into ruin representing a two standard deviation (or 2.5% probability) event.

Assets are held against liabilities plus surplus. Therefore, surplus should be represented in the liability benchmark. For example, if the outright stability of surplus were the goal, and surplus were 12% of assets, a fixed liability of 12% in cash should be incorporated into the liability benchmark.

SYMMETRY VERSUS ASYMMETRY

The standard deviation measure is the cornerstone of this method. It allows the capture of many different types of risk and their assimilation into one overall risk measure. The potential shortcomings of this type of risk measurement occur when there are a limited number of assets and liabilities involved and they have very asymmetric distributions.[6] Explicit stress testing as described earlier can be used to address this situation.

In that vein, the approach shown here of using standard deviations and correlations to calculate an overall standard deviation awaits eventual replacement by even more computer intensive—but less intuitive—simulation models.[7] Such models would permit specific recognition of the non-normal distribution of numerous variables.[8] However, an overall enterprise approach, with specific stress testing incorporated as constraints, does not need to wait.

CONCLUSIONS

A standard deviation approach allows the distillation of many types of risks into one statistic while recognizing their interdependencies.

Risk and return must not be separated, otherwise another risk is introduced that risk will be taken where it is not optimally rewarded. Perhaps the ultimate risk is that insufficient risk or the wrong type of risk is taken, and an insufficient return on capital is achieved.

A comprehensive approach to risk and return allows a fair comparison between active asset management decisions and simply taking more risk by adopting a more aggressive, but passively managed, strategic asset allocation.

The comprehensive efficient frontier method is robust for different asset and liability types and allows optimization with respect to both. This technique is general enough to be used for any type of financial institution.

A simplified example demonstrates and enumerates the compelling advantages to be gained by optimizing with respect to both assets and liabilities simultaneously.

Just as assets and liabilities should not be analyzed separately, neither should risk and return. Using a comprehensive approach to enterprise risk and return management will enable actuaries to not only maintain their reputation for risk measurement, but also to move into broader management roles within financial institutions.

[6]Some considerations in using a standard deviation, or value-at-risk, approach are addressed in Beder (1995).

[7]Much the same way as traditional actuarial training in the use of commutation columns has been replaced by more sophisticated software for the calculations of premiums and reserves.

[8]There is also analysis suggesting that correlations between asset classes may be dependent on market direction—see Erb (1991) and Harlow (1991).

REFERENCES

BEDER, T.S. 1995. "VAR: Seductive but Dangerous," *Financial Analysts Journal* 51, no. 5 (September/October):12–24.

ERB, C., HARVEY, C., AND VISKANTA, T. 1991. "Asset Allocation in a Downside-Risk Framework" *Financial Analysts Journal* 47, no. 5 (September/October).

GRIFFIN, M. 1997. "Why Do Insurance Companies and Pension Funds Hold so Few International Assets?" *Journal of Portfolio Management* (Summer):45–50.

HARLOW, W.V. "Forecasting International Equity Correlation," *Financial Analysts Journal* 47, no. 5 (September/October).

JORION, P. 1989. "Asset Allocation with Hedged and Unhedged Foreign Stocks and Bonds," *Journal of Portfolio Management* (Summer):49–54.

JORION, P. 1985. "International Portfolio Diversification with Estimation Risk," *Journal of Business* 58, no. 3:259–78.

LIEBOWITZ, M.L., BADER, L., KOGELMAN, S., AND DRAVID, A.R. 1995. "Benchmark Departures and Total Fund Risk: A Second Dimension of Diversification," *Financial Analysts Journal* 51, no. 5 (September/October):40–8.

NESBITT, S.L. 1991. "Currency Hedging Rules for Plan Sponsors," *Financial Analysts Journal* 47, no. 2 (March/April).

PARKER, G. 1997. "Stochastic Analysis of the Interaction between Investment and Insurance Risks," *North American Actuarial Journal* 1, no. 2 (April):55–84.

TOBIN, J. 1958. "Liquidity Preference as Behavior Towards Risk," *Review of Economic Studies* 67:65–86.

Discussions on this paper can be submitted until October 1, 1999. The authors reserve the right to reply to any discussion. See the Submission Guidelines for Authors for detailed instructions on the submission of discussions.

lion gallons of crude oil in the coast of Alaska. Five years later, a jury in federal court returned a $5 billion-dollar punitive damages verdict against the Exxon Corporation. However, if Exxon did not own the tanker Exxon Valdez, but had contracted its oil transportation with an independent shipping company, it would probably not have had to face the lawsuit. Instead, the shipping company would have gone bankrupt. (The issue of bankruptcy risk is mentioned in Statement c on page 14 of the paper.) Hence, the ''merging'' of a shipping company with an oil company seems to expose the shareholders of the oil company to extra risk.

REFERENCES

ARTZNER, P., DELBAEN, F., EBER, J.-M., AND HEATH, D. 1999. ''Coherent Measures of Risk,'' *Mathematical Finance* 9:203–28.

WIRCH, J.L. 1999. ''Raising Value at Risk,'' *North American Actuarial Journal* 3, no. 2 (April):106–15.

AUTHOR'S REPLY

PHILIPPE ARTZNER*

I thank Professor Shiu for providing the opportunity to clarify the phrase ''a merger does not create extra risk.'' It was deliberately rough and did not say for whom risk may be or may not be created.

The notion of measure of risk is about one party deciding some action in relation to another party possibly concerned by this action, like:

- A financial firm and the government as lender of last resort
- A trader and his company
- An investor and the exchange's clearing house
- An oil producer and society
- A shipping company and society.

What is meant in the subadditivity property is: if society requires 10 as capital from an oil producing company and requires 5 as capital from a shipping company, then society should not require more than 15 as capital of the company formed by merging the former two (unless, as pointed out by Professor Michael Sherris, the captain of the boat of the merged company becomes careless, because he is now member of a company ''with deep pockets'').

*Philippe Artzner, Ph.D., is Emeritus Professor at the Institut de Recherche Mathématique Avancée, Université Louis Pasteur et CNRS, et Laboratoire de Recherches en Gestion, F 67084 Strasbourg, France, e-mail, artzner@math.u-strasbg.fr.

''Enterprise Risk and Return Management for Financial Institutions,'' Mark Griffin and Rick Boomgaardt, April 1999

ELIAS S.W. SHIU*

The authors are to be thanked for this thought-provoking paper. When I teach Chapter 8 of *Financial Economics* (Panjer et al. 1998) in the future, I shall know to where I can refer the students for some interesting examples.

I am puzzled that surplus is only introduced near the end of the paper, like an afterthought. It seems to me that surplus can be readily incorporated into the model through the ''funding ratio'' as presented on page 398 of *Financial Economics*. It is assumed in Section 8.4 of *Financial Economics* that there is a given liability, which can be modeled as a negative asset. Here, there are several liabilities that can be sold or issued by the financial institution. Markowitz's mean-variance analysis, or the equivalent mean-standard deviation analysis, is used to determine optimal compositions of liabilities as well as optimal compositions of assets.

I find the statement ''it appears P&C insurers should use riskier assets than life insurers because their liabilities are riskier'' intriguing. Markowitz's model can be justified only under two assumptions. One assumption is that the financial institution has a quadratic utility function. However, it is not a reasonable utility function because the financial institution would have less risk tolerance as its wealth increases. The alternative assumption is that the asset and liability returns have a joint multivariate normal distribution. Before we make practical applications of the results from the model, we should determine how far the returns, as random variables, deviate from this assumption.

It may be useful to point out that Markowitz's model is a one-period model. In general, asset and liability management is a long-term, multiperiod problem. Let me quote from Luenberger (1998, p. 417): ''Conclusions about multiperiod investment situations are not mere variations of single-period conclusions—rather they often *reverse* those earlier conclusions. This makes the subject exciting, both intellectually

*Elias S.W. Shiu, A.S.A., Ph.D., is Principal Financial Group Professor of Actuarial Science, Department of Statistics and Actuarial Science, The University of Iowa, Iowa City, Iowa 52242-1409, e-mail, eshiu@stat.uiowa.edu.

and in practice. Once the subtleties of multiperiod investment are understood, the reward in terms of enhanced investment performance can be substantial.'' Great advances in determining optimal investment strategies in multiperiod models have been made since the appearance of Merton (1969); also see Part II of the Merton book (1990). Two recent books devoted entirely to this area are Korn (1997) and Sethi (1996). Two recent papers related to the subject matter of the present paper are Browne (1997, 1999). Unfortunately, most of these works require heavy mathematical machinery such as dynamic programming in continuous time (stochastic control theory) and the Hamilton-Jacobi-Bellman equation. An attempt to derive some of these results using more elementary mathematics can be found in Gerber and Shiu (1997, 2000).

REFERENCES

BROWNE, S. 1997. ''Survival and Growth with a Liability: Optimal Portfolio Strategies in Continuous Time,'' *Mathematics of Operations Research* 22:468–93.

BROWNE, S. 1999. ''Beating a Moving Target: Optimal Portfolio Strategies for Outperforming a Stochastic Benchmark,'' *Finance and Stochastics* 3:275–94.

GERBER, H.U., AND SHIU, E.S.W. 1997. ''On Optimal Investment Strategies,'' *Rivista di Matematica per le Scienze Economiche e Sociali* 20:133–51.

GERBER, H.U., AND SHIU, E.S.W. 2000. ''Investing for Retirement: Optimal Capital Growth and Dynamic Asset Allocation,'' *North American Actuarial Journal* 4, no. 2 (April), forthcoming.

KORN, R. 1997. *Optimal Portfolios: Stochastic Models for Optimal Investment and Risk Management in Continuous Time.* Singapore: World Scientific.

LUENBERGER, D.G. 1998. *Investment Science.* New York: Oxford University Press.

MERTON, R.C. 1969. ''Lifetime Portfolio Selection under Uncertainty: The Continuous-Time Case,'' *Review of Economics and Statistics* 51:247–57. Reprinted as Chapter 4 in Merton (1990).

MERTON, R.C. 1990. *Continuous-Time Finance.* Oxford: Blackwell.

PANJER, H.H., ed. 1998. *Financial Economics: With Applications to Investments, Insurance, and Pensions.* Schaumburg, Ill.: The Actuarial Foundation.

SETHI, S.P. 1996. *Optimal Consumption and Investment with Bankruptcy.* Hingham, Mass.: Kluwer.