Liability-Driven Investment Strategies for Pension Funds

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For many years, pension fund management focused exclusively on managing the assets of the plan. The "perfect storm" that occurred at the beginning of this decade, however, caused asset values to decline as liabilities soared and triggered a steep decline in the funded status of pension funds globally. This experience fostered the development of liability-driven investing—the recognition that pension fund assets should be chosen to match the behavior of a fund's liabilities.

If I am managing institutional money for pension funds, it makes a lot of sense for me to understand the pension fund's ultimate purpose. Pension fund managers are looking for answers from the asset management side to be able to provide pensions 20, 30, or 40 years down the road. The asset management side can talk about alpha, beta, dynamic allocation, and so on, but it tends to neglect the fact that its ultimate purpose is to provide enough assets to pay for liabilities decades in the future. The world of liability-driven investments (LDI) is a useful paradigm to broaden the overall investment perspective and enhance the solution space for securing payments far in the future.

Before discussing LDI, I will give you some insight into the Swiss pension system. Then, I will review the traditional approach to asset allocation, mean–variance optimization, and surplus optimization, which leads quite naturally into the field of LDI. To discuss LDI, I will take a closer look at liabilities, cash flow, and duration matching.

Swiss Pension System

The Swiss pension system is a three-pillar system. Similar to other countries, the Swiss have a broad and strong first pillar that is designed to cover the essential needs of the population. The goal is to provide a secure, basic existence.

The Swiss, along with many other countries, enjoy a long life expectancy. Because the age pyramid in developed countries is turning onto its head (i.e., fewer people are supporting an increasing number of retirees), it puts a strain on a pay-as-you-go state pension system. In Switzerland, everyone pays a certain percentage (currently 8.4 percent) of their entire salary into the system. The resulting pension amount to be expected from this first pillar has a cap and a floor. So, higher salaries will contribute substantially more into the system than they will ever get out of it. This can be interpreted as an additional tax layer of almost 10 percent.

The second pillar of the Swiss system is a mandatory plan designed to maintain existing living standards. In this part of the system, contributions can be defined by the employer (having to fulfill minimum requirements) and range from 7 to 18 percent. An interesting aspect of these pension funds is that they are legally independent of the sponsoring companies. The sponsoring company can choose to set up a defined-benefit (DB) or a defined-contribution (DC) plan. Since the 1990s, companies have been shifting from DB to DC plans. This change has the unfortunate consequence of moving investment risk away from the sponsoring company (i.e., where one would expect more expert knowledge about investments) to the employee. DC plans are required to guarantee a minimum rate of return each year, which can be adjusted by public authority. DB plans are required to prove that their

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benefits at least match the minimal DC solution. These requirements create complications in the way investments are done. The required guarantee shortens an otherwise very long investment horizon (more than 25 years) to a much shorter time frame (at best a few years). This shortening is because the annual return guarantee, along with a full funding requirement, forces pension fund trustees to focus on meeting the minimum return requirement as soon as possible instead of targeting wealth at the time of retirement. The second pillar of the Swiss system became mandatory for every employed person in 1985. Because of its existence for more than two decades, the system is basically fully funded. This status is a great privilege compared with such countries as Germany, France, and Italy that are starting to set up their second pillar from much lower levels. Typically, one should expect two to three decades of pension savings before a country can claim to have a fully funded pension system.

The third, much smaller pillar of the Swiss system provides some tax advantages to an individual who wants to save even further voluntarily. The political will is for the first two pillars to provide pension payments that equal approximately 60 to 70 percent of the last wages earned before retirement.

Before 1995, the system experienced problems concerning the portability of pension benefits. Changing jobs without losing contributions was difficult in the second pillar of the pension. Now, the pension is completely portable. If employees change companies, they transfer their (i.e., employee and employer) savings, including all the investment returns, into the pension fund at the new company. Portability, however, is not without issues. Employees who leave a fully or overfunded fund get their share of the accumulated wealth but do not share in any surplus. Employees who leave an underfunded fund, however, get their share of the accumulated wealth without participating at least partially in the underfundedness of the pension fund.

Similar to the Swiss, the Germans have adopted a three-pillar pension system, but they are many years behind in terms of funding their second pillar. Additionally, of the approximately 36 million working Germans, almost half do not have second pillar–oriented savings. Compare that with Switzerland, where 100 percent of the working population is required by law to pay into the second pillar. With France and Italy in a position similar to Germany (which collectively account for about 80 percent of the European population), an obvious need exists to increase savings substantially and, of course, to find appropriate investment strategies that create opportunities for the asset management industry in general.

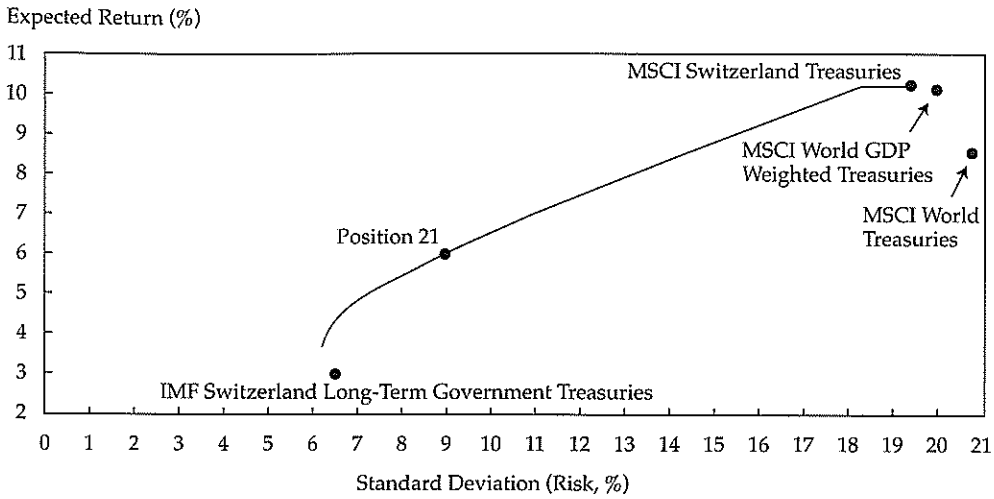
Liability-Driven Investing

Based on the basic paradigm of investment management, **Figure 1** shows an efficient frontier, with a limited universe of investment components, such as long-term Swiss government bonds, Swiss equities, and global equities. Position 21, which represents one possible portfolio on the efficient frontier, is composed of 17 percent Swiss equities, 25 percent global equities, and almost 60 percent Swiss bonds. Based on the underlying assumptions, this portfolio would have an expected return potential (expressed as an arithmetic mean) of 6 percent with a volatility (i.e., standard deviation) of roughly 9 percent (or a mean return of 5.47 percent and standard deviation of 8.46 percent assuming continuous compounding).

Investors, of course, are not interested in just average returns but also must consider the range of possible outcomes. With a volatility of 9 percent, 90 percent of potential outcomes in the first year are expected to fall in a band of –8 to 21 percent return per year. **Table 1** translates these returns into long-term effects on wealth. As shown, when expressed in terms of terminal wealth, the initial investment is expected to end up with a value of 298 and, in 90 percent of cases, the bandwidth of outcomes is between 161 and 551.

In the next step, this analysis can be expanded with a simplified modeling of liabilities to help answer the question of how likely the portfolio is to generate returns beyond some minimum threshold. The simplest way to introduce liabilities into standard mean–variance optimization is to have a fixed negative return that must be provided for out of the portfolio. Starting with the same Position 21 portfolio used in Figure 1, assume that every year the insured receives a guaranteed return of 4 percent. (see **Table 2**). This payout (i.e., guaranteed return assumption) has been applied in Switzerland for many years, although in the last few years the required return guarantee has been lowered to below 3 percent. If a pension fund starts in a fully funded position (assets = liabilities = 100) and has an expected return of 5.6 percent and a (negative) liability return of 4 percent, the band around expected returns will behave as shown in **Table 3**. Given the small difference between the two returns, however, the uncertainty of this future expectation implies a much larger confidence band for expected wealth compared with the situation without liabilities. Especially troubling would be a situation of wealth substantially below 100 because it would represent a situation in which assets are not covering liabilities, and thus an underfunding situation would occur for this pension fund.

Figure 1. Efficient Frontier of Swiss Government Bonds, Swiss Equities, and Global Equities



Notes: MSCI Switzerland and MSCI World indices are net of taxes. MSCI World GDP and MSCI World indices are in Swiss francs.

Table 1. Development of Terminal Wealth from an Investment in the Position 21 Portfolio

Percentile	1 Year	2 Year	3 Year	5 Year	7 Year	10 Year	15 Year	20 Year
95th	121.92	135.57	149.98	179.15	211.43	269.49	389.75	551.55
50th	105.47	111.42	117.67	131.28	146.58	172.71	227.58	298.96
5th	92.19	92.18	93.17	97.25	102.48	111.65	134.61	161.53

Note: Year 0 equals 100.

Table 2. Development of Terminal Wealth with an Assumed 4 Percent Payout in the Position 21 Portfolio

Percentile	1 Year	2 Year	3 Year	5 Year	7 Year	10 Year	15 Year	20 Year
95th	117.04	125.72	134.34	150.06	167.83	196.93	255.57	335.77
50th	101.25	102.71	104.23	107.58	111.29	117.55	131.08	147.30
5th	88.50	84.73	81.85	77.47	74.05	68.48	61.61	53.44

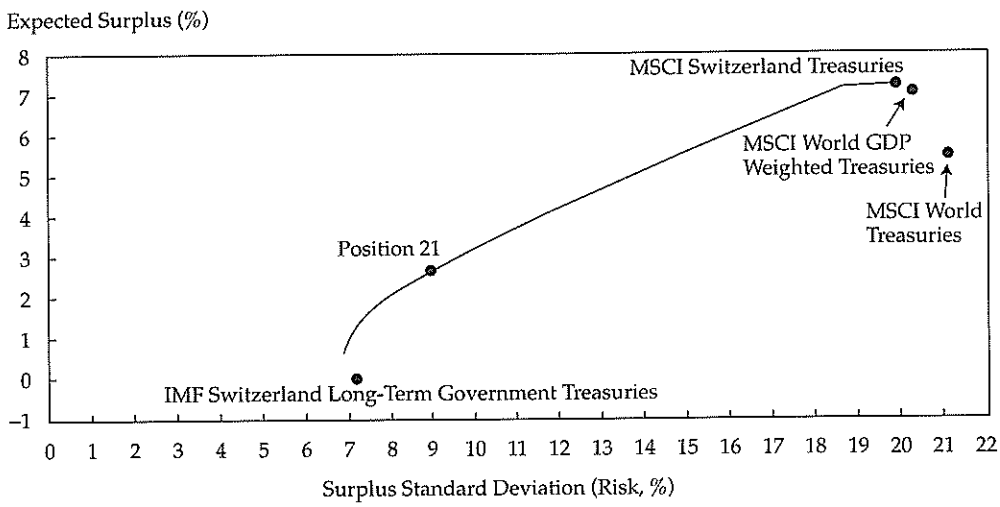
Note: Year 0 equals 100.

Table 3. Returns on a Fully Funded Pension Fund in Which Liabilities Are Equal to Inflation (Position 21 Portfolio)

Percentile	1 Year	2 Year	3 Year	5 Year	7 Year	10 Year	15 Year	20 Year
95th	19.95%	15.47%	13.54%	11.64%	10.64%	9.75%	8.93%	8.44%
50th	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34
5th	–7.50	–3.91	–2.28	–0.61	0.29	1.09	1.86	2.32

An interesting exercise is to analyze how a pension plan would do in three scenarios: fully funded, underfunded, and overfunded. For this example, instead of using a fixed liability return, assume that the liabilities are approximated by the Swiss inflation rate. If the portfolio shown in **Figure 2** is kept over the long term, what will happen to its funded status as a pension fund? As Table 3 shows, the pension starts out being fully funded. Over the long term, the expected surplus should increase because the expected return is above the zero line every year. In the first year, for example, the fund is expected to grow 5.34 percent with a 90 percent probability of returns being between 19.95 and –7.5 percent. After five years, the fifth percentile returns turn into positive territory.

Figure 2. Fully Funded Pension Fund in Which Liabilities Are Equal to Inflation



Notes: MSCI Switzerland and MSCI World indices are net of taxes. MSCI World GDP and MSCI World indices are in Swiss francs.

A more difficult situation involves a pension fund that starts with a substantial deficit. Getting into such a situation may be easier than investors realize. Many funds held low equity weightings during the early- to mid-1990s. But as market performance improved toward the end of the 1990s, funds increased the equity weightings because of a higher risk tolerance and took a full hit when markets corrected. Some well-known insurance companies in Switzerland were in this difficult situation. Unfortunately, the options to act are quite limited in an underfunded situation. A conservative asset allocation approach (i.e., choosing a point on the left side of the expected surplus curve) makes it difficult to move to a positive expected surplus in the future despite projected asset returns well above the liability return proxied by the inflation rate. Other options are to take a lot more risk than should be taken given the underfundedness and hope for great equity results (certainly not to be recommended), increase contributions from sponsors and beneficiaries, and/or decrease future benefits. The higher the level of assets in relation to the current salaries (which form the basis of contributions), the more difficult it is to correct the fundedness problem. Of course, to start with an overfunded situation and have expected returns above liabilities would be a great situation to further bolster reserves in the pension fund. Experience shows that quite often the issue becomes one of complacency. If pension funds have reserves that substantially exceed the amount to cover future liabilities, the danger is that the trustees lose focus on return targets, diligent risk taking, and tight cost control.

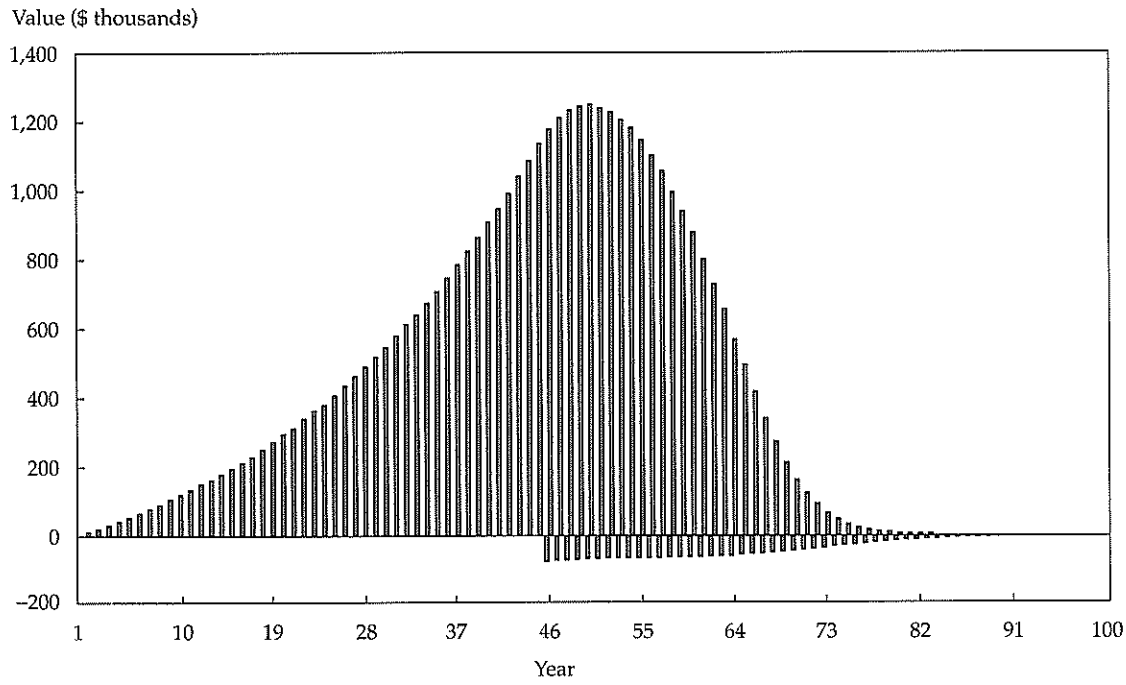
Understanding Liabilities

The realization that equity markets could decline by 40 percent in a rather short time period and, consequently, an overfunded fund become seriously underfunded prompted a serious reevaluation process among pension fund managers. What could and should be done under such circumstances? As the thought process evolved, some pension managers began to dig deeper into understanding liabilities and look for better solutions to bring assets and liabilities more in line.

A logical starting point is to consider the role of actuaries, who are responsible for projecting the future benefits for members of pension funds. They help determine the amount of money that needs to be put aside today to cover future liabilities (discounted back to the present).

Consider how one individual in a pension fund looks to an actuary. **Figure 3** shows the pension fund of an individual who saves $10,000 a year from age 20 (Year 1) to age 64 (Year 45). The savings will accumulate through time by a 4 percent expected rate of return, adjusted for the individual's probability of surviving each year. In retirement, the individual will have an amount slightly above $1,133,000, which continues to grow at 4 percent. At the same time, our individual will start expensing $70,000 per year (adjusted again for survival probability) until death. This calculation is the basic approach to valuing pension assets. Gender introduces complications, but in general, a pension fund can be summed up with this method.

Figure 3. Individual Pension Fund Based on Savings, Expected Return, and Maximum Projected Life Expectancy



Note: Cash flow is adjusted by using German mortality tables for males.

The surprise for asset managers is how sensitive liabilities are to small changes in interest rates. Consider an investor who needs $1.1 million of accumulated capital to fund retirement at age 64. At a 4 percent discount rate, that individual would need to set aside about $201,000 at age 20 to fund the future liabilities associated with that amount. But a relatively modest decrease in interest rates to 3 percent increases the present value of the liability more than 30 percent to $267,000. Conversely, a modest increase in interest rates decreases the liability in a similar way. This sensitivity should not be a big surprise, because the fund is essentially acting as a bond (annuity) with a very long maturity. The interest rate sensitivity of this bond (i.e., the duration) would be approximately 33 years. This view, however, has two important implications. First, durations that long are extremely sensitive to interest rate changes. Second, a typical bond portfolio's duration is nowhere close to 33 years.

It is interesting to combine the asset and liability views and bring together asset managers and pension trustees to address the issues. Consider how assets and liabilities behave in a typical pension fund. **Table 4** shows the starting point and two hypothetical scenarios of a fund with 20 percent in equities, with an expected return of 8 percent, and 80 percent in bonds, with an expected return of 4 percent. The duration of its bond investments is 6 years; its liabilities, 20 years. At the starting point, the fund is fully funded, with assets equal to the present value of future liabilities equal to 100. The first hypothetical scenario represents the best case from the perspective of the asset manager—the stocks go up in value by 20 percent while interest

Table 4. Effect on a Fully Funded Pension Fund of Changes in Assets and Liabilities

Starting Point		
Asset	Liability	
20.0%	100.0%	
80.0	0.0	–> Fully funded
100.0%	100.0%	
Best of Two Worlds		
Asset	Liability	
24.0%	140.0%	
89.6	–26.4	–>Underfunded
113.6%	113.6%	
Equity (+); Bonds (–)		
Asset	Liability	
24.0%	60.0%	
70.4	34.4	–> Overfunded
94.4%	94.4%	

rates decline by 2 percent. Total assets, therefore, grow to 113.6. A decline in interest rates, however, causes the present value of liabilities to increase to 140, leaving the fund –26.4 percent underfunded. Asset managers would (rightly) argue that the performance of the best-case scenario is attractive—and even more so if they claim to be total return managers who try to add returns beyond the risk-free rate. The pension fund will have a substantial deficit, however, and investors should not be happy with the resulting funding status. The second scenario shows the result of interest rates rising 2 percent instead of declining. Higher interest rates translate into a reduction of the present value of liabilities and leave the pension fund overfunded by 34.4. This scenario would be much less desirable from the asset managers' perspective.

The potentially large difference in changes between the asset and liability of the pension fund balance sheet forms the basis for the discussion about liability-driven investments. Pension trustees rightly ask what can be done to avoid potential surprises from this mismatch.

The first step is to examine the factors driving the dynamics of the situation. By understanding the relevant factors, a manager may be able to provide investment solutions that help mitigate the negative effects of a pure return-oriented investment approach. Factors that influence the level of future pension payments are longevity, inflation, wage growth, and service costs (among many costs of consulting, investments, and actuarial work). The value of future liabilities is determined by the level of the risk-free discount rate plus additional spread components.

A major concern for the sponsoring company of DB as well as DC plans is inflation, because future payouts are generally tied to inflation. Unfortunately, in the case of Switzerland, the vast majority of company-sponsored plans do not really worry about inflation (i.e., real returns on investments). The focus is on just delivering the necessary guaranteed return and not looking beyond that. The price of neglecting to consider inflation will be felt by the pension fund beneficiaries at retirement, when it is too late to add in a major way to accumulated savings.

Inflation affects liabilities through its effect on wage growth, which is linked to final average pay and forms the basis for determining pension benefits. Interest rates should be decomposed into expected inflation and real interest rates. It is important to realize that liabilities are highly sensitive to changes in interest rates and inflation, and as a result, both exposures should be taken into account. The marking to market of liabilities allows a more economic rather than pure actuarial point of view and introduces much more volatility on the perspective of fundedness than generally perceived.

The concept of dual duration was developed to address the sensitivity of liabilities. Dual duration recognizes that every asset has a separate sensitivity to both real interest rate risk and inflation risk. By considering dual duration, it becomes possible to create a hedging portfolio of assets that has the same sensitivity to both durations as the plan's liabilities. Of course, in so doing, the investor ends up with a portfolio consisting mostly of bonds. As a result, the expected return of the fund will be much lower than it would be without a substantial equity presence, although it will have greater certainty with respect to its funding status. Return expectations, however, can be improved on average by combining the hedging portfolio with a riskier portfolio. This combination would have the effect of moving the fund up and to the right on the surplus frontier. Certain issues would have to be addressed before taking these steps: specifically, the risk tolerance of the trustees, the current funding level of the pension fund, and the size of the liabilities in relation to the balance sheet of the sponsoring company.

Immunization and Cash Flow Matching

Immunization represents the first attempt to deal with the problem of asset/liability mismatches. With immunization, the goal is to simply require that assets and liabilities have the same sensitivity to interest rate changes (as measured by duration). This approach eliminates the exposure pension plans have to a small parallel shift in the yield curve. Immunization, however, does not protect a fund from nonparallel changes in the shape of the yield curve. These problems can be overcome somewhat by recognizing the effect of convexity and by using such higher-order duration measures as partial durations or key rate durations that measure the degree of interest rate sensitivity for various parts of the yield curve.

Cash flow matching is a richer approach to the asset/liability matching problem. With cash flow matching, managers try to determine a portfolio of bonds in which cash flows replicate those of the liability stream. In its simple forms, cash flow matching would require a static optimization, which is a single investment decision made today, along with the assumption that reinvestment and borrowing rates are known in advance. More sophisticated quantitative techniques make use of dynamic

optimization combined with simulated reinvesting and borrowing rates. The more dynamic the approach, however, the greater the amount of trading and the higher the level of transaction costs. In addition, more frequent trading can lead to a greater number of small mismatches between assets and liabilities driven by the need to trade in round lots.

To apply immunization in a real-world situation, consider an underfunded pension plan with a relatively high allocation to equities. A number of options are available to handle this situation. The first option would be to do nothing. The advantage of high equity allocations is that on average and over long periods, the expectation of higher returns is reasonable. Conversely, equities are highly volatile in relation to fund liabilities. Also, equities generally have a low sensitivity to changes in inflation and interest rates. So, in the worst of all possible worlds—a simultaneous decline in equities and interest rates—funding levels can deteriorate even more. The question becomes, how long could a manager stay with a high equity allocation before the trustees, plan sponsor, or regulatory authorities insist the situation be corrected?

But if a high equity exposure must be maintained, several solutions with second-order effects could be considered. The manager could attempt to find diversifying sources of market exposure. In addition, he or she could try to add alpha through equity style rotation (e.g., large/small, value/growth, and momentum strategies) or any other form of exploiting misvaluations in market segments and/or individual securities. Of course, it is well known that active strategies to generate alpha do worse on average than the simple indexation of funds.

A second option would be to increase the bond weight to reduce the general volatility of the assets. This option would diminish the outperformance potential relative to liabilities but would have the advantage of reducing the duration mismatch between assets and liabilities. Also, by assuming a higher return on assets than on liabilities, the speed on the path to full funding would slow down considerably. In addition, or as a substitute, swaps could be used. They have similar characteristics to bonds, which would allow the separate hedging of interest and inflation risk. They are more flexible for tailoring solutions (i.e., better cash flow and/or duration matching) and even allow leverage that could support the duration matching with less need for additional funds. The use of swaps, however, is not without its costs because it introduces substantial counterparty risk, an issue that came up fiercely in the financial crisis that began in 2007. Measures that could provide second-order benefits would be an optimized international bond composition, ideal curve positioning, credit exposure, and directional currency and interest rate positioning.

Conclusion

On a final note, bringing assets and liabilities into the overall pension fund picture is an important exercise for all involved parties and a prerequisite to properly managing pension money. Combining older and newer thinking on the issues is a challenge. But the result may well reduce explicit and/or hidden costs and either increase the soundness of funding or decrease underfundedness in a well-managed way beyond aggressively betting on high returns and hoping for the best.

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Question and Answer Session

Roman von Ah

Question: Are Switzerland and Germany actively introducing liability-driven investments?

von Ah: In Switzerland, it is hardly visible. The reason is related to the need to pay guaranteed returns on the pension assets. At present, targeted returns generally are in the range of 4 to 4.5 percent (i.e., regulatory minimal return plus additional return requirements to cover costs, longevity and others). But if managers are investing in 10-year riskless bonds with a yield of 2.7 percent, they will be short by about 2 to 2.5 percent a year. This situation basically forces them into equities. In Germany, their focus is on developing the second pillar. Interest rate sensitivity represents a second- or third-order consideration.

Question: In your experience, what would you say is the duration of the liabilities of a typical pension fund?

von Ah: I would estimate that it is solidly above 20 years.