Performance measurement for pension funds

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1. Introduction

Pension funds around the world suffered dramatically from fallings stock markets in the period 1999-2003. For example, Wilshire associates report in May 2003 that 89% of the US S&P 500 defined benefit plans were underfunded at the end of 2002[2]. At the end of the fiscal year 2003, total underfunding in the US private pension funds exceeded $350 million. Other countries with well-developed pension industries, such as Canada, the UK and several other European countries, show similar statistics. The extent of the damage varies by country. The main cause of the problems was a considerable exposure to stocks. In particular, in the 90s of the previous century, pension funds around the world switched from rather conservative asset allocations towards more exposure to equity. Despite the severity of the crises, media attention was mostly limited to some coverage in the financial press. Most beneficiaries of pension funds are only remotely aware of the impeding danger for their future pensions.

The pension fund crises attracted a lot of media attention, and several solutions have been tried by individual pension funds. Despite the fact that the fall in stock market prices was the major cause of the crises, few funds choose to reduce the exposure to the stock market. Many plan sponsors added additional funding to increase the funding levels, although their ability to do so depends of course on their own financial health. In the US, the Pension Benefit Guarantee Corporation (2003) reports to have bailed out of several pension funds. Other actions taken by the pension funds are the reduction of future pension claims by limiting indexations, changing the mechanism for accruing benefits, changing from defined-benefit to defined contribution schemes, and closing the funds for new employees. In other words, most effort has been directed to the liabilities rather than changing asset allocation policy. For example, in the table 1 we report the average asset allocation for pension funds in the Netherlands. As can be seen in this table, the average allocation to equity dropped from 41.9% in 2001 to 34.9% in 2002, but increased again to 38.1% in 2004.

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[2] Quoted from *Pension Benefits*, Vol 12, No. 7.

Tabel 1: Pension funds in the Netherlands

	1997	1998	1999	2000	2001	2002	2003
Cash	5,430	4,821	3,543	5,437	4,940	11,551	10,836
Bonds	181,411	195,825	188,361	206,340	201,739	206,592	206,937
Equity	105,881	140,806	204,313	190,715	192,924	149,231	184,942
Real Estate	31,608	35,498	41,535	47,965	49,609	46,564	47,788
Other investments	8,830	9,803	13,512	13,300	11,565	13,358	26,545
Total investments	333,160	386,753	451,264	463,757	460,777	427,296	477,048
Average funding ratio	126	133	139	132	118	101	104
% underfunded pension funds			0.4%	0.3%	1.5%	10.2%	4.3%

The response of the pension fund industry to the stock market crises in addition to the already existing trend towards defined contribution plans shifted more responsibility and risks to the individual. As a result, the risks are now more and more on the shoulders of the individual. However, these individuals still have to solve the same problem as the defined benefit pension plans: how to invest in such a way to attain a decent level of future retirement benefits. Rooij, Kool and Prast (2005) investigated the preferences of a sample of 1000 individuals and found that the majority prefers a defined benefit plan over a defined contribution plan. In addition, they found that the majority of these individuals wants to avoid the responsibility for investment choices. Apparently, investors are aware of their limited ability to make decisions in a defined contribution plan. It also hard to believe that individuals are better suited for this job than pension fund managers are. There is a considerable literature on the irrational trading behavior of individual investors. For example, Barber and Odean (2002) report that investors trading in individual securities show an excessive turnover in their portfolios. Furthermore, they show that trading has a negative impact on portfolio performance. The 20% investors who trade most earn a return of 11.4%, whereas the market returns 17.9%.

In our opinion, pension funds perform a useful role in providing collective pensions for individuals. Therefore, we believe that many policy responses after the market crash have been misdirected. In particular, we believe that the asset allocation of pension funds should have been realigned with the risks of the liability structure. Furthermore, the valuation of the pension liabilities should be reconsidered in order to make sure that the assumptions made in valuing the future cash flows are matched with the reality of investment markets. However, our most important suggestion is that the performance measurement systems of pension funds should be redesigned in order to focus investment managers on the primary objective of pension funds. This should result in the use of a so-called liability-driven benchmark for the performance and risk-management of the investment portfolio, in order to ensure that the investment policy remains focused on serving the pension beneficiaries. The primary focus of the pension fund should be on providing reliable pension benefits. The reality is that pension funds are trapped between the objective of the beneficiaries and that of the plan sponsor. The plan sponsor desires to minimize its contributions, which is associated with a lower probability of pensions being paid out. The beneficiaries like to have higher pensions, which usually cannot be realized without higher sponsor contributions. An often-used resolution to this conflict is to choose an asset portfolio with a higher expected return, which makes it possible to have both lower sponsor contributions and higher future expected benefits. Unfortunately, this solution results in additional risk for the beneficiaries. Depending on the solvency of the sponsor and his willingness to pay, the additional risk is eventually levied on either the sponsor or the beneficiaries. This can lead to undesirable circumstances, where the sponsor is not able or willing to compensate deficits in the pension fund. In these circumstances, government agencies such as the PBGC may have to bear the losses, or, in the absence of such an agency, the pensions have to be lowered.

The objective of this paper is to develop a performance measurement framework that supports more reliable pension claims from the perspective of pension beneficiaries. This performance measurement framework has two important elements. The first element is the benchmark, which is based on cash flow matching. The second element is a performance attribution model, which facilitates analyzing the causes of good and bad performance.

This study is structured as follows. In section 2, we discuss the nature of pension fund liabilities and the risk factors associated with pension liability risk. In section 3, we discuss the relation between assets and liabilities, and what risk measures can be used to reduce the risk of the pension fund. Finally, in section 4 we develop our performance attribution model that aims to focus investment managers on the primary objective of the pension fund.

2. Pension liabilities

Although pension funds around the world are structured in a variety of ways, the main issue is whether they are defined benefit or defined contribution plans. Pension claims in a defined benefit plan are largely determined by the wages earned by the beneficiary and the number of years of employment. With a 'final pay system', the pension claims are based on the wage earned in the last year. However, it is also common to have claims as a function of past wages earned, such as the average wage earned during the years of employment. Pension claims in a defined contribution plan are solely determined by the returns earned on the individual's investment portfolio. Pension funds with defined contribution plans levy the investment risks on the individual plan beneficiaries. Therefore, risk management and asset-liability management are only of indirect concern to these plans.

A correct valuation of the liabilities is crucial in managing pension funds. The value of the liabilities serves as a benchmark for the level of assets needed to serve the future cash flows of the pension fund. The valuation starts with an appropriate estimate of the future cash flows resulting from the current promises made to beneficiaries. Next, the present value of these cash flows is calculated using a discount rate. This discount rate effectively functions as a benchmark for the minimum acceptable return to be achieved on the assets (See Sortino, Van der Meer and Plantinga, 1999). If the assets do not yield a sufficient return, the future pension benefits cannot be realized without further sponsor contributions. Proper valuation of liabilities and accordingly funded pension funds create the potential for reliable pensions, with benefits aligned to the expectations of the participants. However, the actual realization of reliable pensions is a matter of an appropriate investment strategy. In order to keep the focus of portfolio managers on the objective of the pension beneficiaries, the investment strategy that gives the best chance of realizing the objective has to be embedded in the asset benchmark.

In this article, we focus on the perspective of a pension fund with a defined benefit plan. Managing a defined benefit plan is complicated, since it involves risk sharing between the beneficiaries and the plan sponsor, and risk sharing between different generations of beneficiaries. In order to value these pension liabilities, it is useful to make a distinction between nominal liabilities and real liabilities. Nominal liabilities are promises to pay future cash flows expressed in nominal terms. Real liabilities are promises to pay future cash flows with a fixed purchasing power. Typical pension liabilities are likely to be a mix of both nominal liabilities and real liabilities. For practical purposes, the value of nominal liabilities is the present value of its future cash flows using nominal risk-free discount rates, preferably zero-coupon yields on government securities. The value of real liabilities is obtained with the use of real yields on inflation-linked zero-coupon government bonds.

Pension liabilities are exposed to several sources of risks, such as operational risk, unexpected demographic developments, unexpected developments in inflation and real interest rates. Interest rate risk is one of the most important risk factors as it affects both assets and liabilities. Therefore, it plays an important role in choosing an appropriate asset portfolio. Since real pension liabilities and nominal pension liabilities differ with respect to the nature of the interest rate risk, it is important to make the distinction between these types of liabilities. The real pension liabilities are subject to uncertainty in real interest rates, and the nominal pension liabilities are subject to uncertainty in real interest rates and future inflation developments.

3. Asset-Liability Modeling

An asset-liability model (ALM) is a model of the assets and liabilities of a financial institution that facilitates decision-making with respect to asset allocation and the properties of the liabilities. A crucial feature of these models is the interdependence between asset and liabilities: ALM is an integrated approach to model both assets and liabilities. The interdependence can be obtained through different modeling approaches, such as surplus models, where the surplus of the pension portfolio is optimized in terms of its expected utility or some alternative value function. This approach has been advocated by Ezra (1991) and Sharpe and Tint (1990). Since the surplus is usually not owned by the plan beneficiaries, the surplus-driven models do not automatically lead to strategies that are beneficial for the beneficiaries, unless the funds are endowed with a considerable surplus.

Reliable pensions can be obtained by using a strategy that minimizes the risk of underfunding. The most obvious strategy is based on creating an asset portfolio that replicates the cash flows of the liability portfolio. Although cash flow matching is used in practice, practical limitations have motivated many to use duration matching strategies as an alternative. In this article, we focus on cash flow matching strategies, although the general idea can also be obtained with a duration matching strategy. A cash flow matching strategy relies on the idea of buying assets that generate cash flows at the scheduled date of paying liabilities. Such strategies have been promoted and used with success by life insurance companies in other to cover their nominal liabilities. For pension funds cash flow matching has not been considered as a feasible strategy due to a lack of index-linked bonds. However, quite recently index-linked bonds and their potential use for pension funds has gained renewed interest, as the availability of index-linked bonds has increased in recent years. Several authors have suggested the potential benefits of TIPS for pension funds[3]. Critics may argue that the availability of inflation-linked bonds is only limited and therefore not useful in a feasible investment strategy. In addition, they may argue that the inflation index used in the inflation-linked bond may differ from that used in the particular pension contract. Although this critique is indeed relevant to some extent, more pension funds using matching with real bonds can trigger additional supply of inflation-linked bonds by governments. There exists also a growing market of inflation-linked swaps that can be used as a substitute for inflation-linked bonds. Furthermore, the mismatch between the inflation index used in the bonds and in the pension contract is likely to be less severe than the mismatch between the use of a nominal bond or equity and the inflation sensitivity of the pension liabilities.

In order to analyze assets and liabilities, we follow Siegel and Waring (2004) who consider the sensitivity of bonds relative to changes in the real rate and in the inflation expectations[4]. Phoa (1999) finds that using nominal duration for inflation-linked bonds gives misleading results. The value of an inflation-linked bond is not affected by changes in the expected inflation, since inflation affects the nominal future cash flow to be paid out as well as the nominal discount rate. Therefore, in contrast with nominal bonds, the sensitivity of real bonds with respect to inflation expectations is zero. A meaningful approach is to make a distinction between the real rate duration and the inflation duration.

Using Fisher's decomposition of interest rates, Siegel and Waring (2004) derive duration measures that capture the sensitivities for both changes in inflation and real rates, the so-called 'dual duration concept'. In the analysis of Siegel and Waring, expected inflation and the inflation risk premium are considered as one. The inflation duration of a bond is the percentage change in price for a small change in the level of inflation (or the inflation risk premium). For a nominal zero coupon bond with maturity T, the inflation duration is equal to:

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[3] See for example, Waring (2004).

[4] The concept of dual durations for liabilities has been developed earlier by Goodman and Marshall (1988) and for equity by Leibowitz (1986). Laatsch and Klein (2005) also discuss the difference between the sensitivity of index-linked and nominal bonds.

$$D_{\pi} = -\left(\frac{1}{P}\right)\left(\frac{dP}{d\pi}\right) = (1+i)T \; , \qquad (1)$$

where π is the inflation rate (including the inflation risk premium), and i is the real interest rate. The real rate duration is equal to:

$$D_{r} = -\left(\frac{1}{P}\right)\left(\frac{dP}{dr}\right) = (1+\pi)T \; . \qquad (2)$$

For an index-linked bond, the inflation duration is equal to

$$D_{\pi} = 0 \; , \qquad (3)$$

and the real duration is:

$$D_{r} = \frac{T}{1+r} \; . \qquad (4)$$

In this analysis, nominal interest rates, real interest rates and inflation expectations are independent of the investment horizon. In other words, the term structure of interest rate and inflation is flat, and moves in a parallel fashion. In the remainder of this article, we will also use this assumption, although for practical purposes, it may be necessary to extend the analysis to capture different shapes and movements of the term structure.

We illustrate the importance of the dual duration concept with the following example of an imaginary pension fund. This pension fund has an inflation-linked liability over five years equal to 1000 dollars in terms of purchasing power at t = 0. The nominal amount to be paid out depends on the annualized inflation rate from t = 0 to t = 5, $i_{0,5}$. The nominal cash flow paid out at t = 5 equals $1000*(1+i_{0,5})^5$. The current market value of this liability is equal to its present value based on the real rate. In table 2, we present the current interest environment for this example. We assume that the current real rate equals 2%, expected inflation is also 2%, and the inflation risk premium is equal to 1.25%. Consequently, the current nominal interest rate must be (1.02*1.02*1.025)-1 = 5.34%. Given these assumptions, the present value at t = 0 of the real (indexed) liability equals $1000/1.02^5$ = 905.73. We also consider a second pension fund, with only nominal liabilities. This pension fund has an obligation to pay 1000 at t = 5. The present value of this obligation is $1000/1.0534^5$ = 770.94. In table 2, we present alternative interest rate scenarios and the impact of these scenarios on the value of the liabilities. These scenarios show that real rates may move in opposite directions from nominal rates.

Table 2: Present value of real liabilities under different scenarios

	Current parameters	Scenario 1	Scenario 2	Scenario 3
Real rate	2.00%	3.27%	2.00%	1.00%
Expected inflation	2.00%	1.00%	1.00%	5.00%
Inflation risk premium	1.25%	1.00%	0.20%	1.25%
Nominal rate	5.34%	5.34%	3.23%	7.38%
Value of real liabilities	905.73	851.60	905.73	951.47
Value of nominal liabilities	770.94	770.94	853.21	700.60

Scenario 1 shows an increase of the real interest rate to 3.27% and a decrease in both expected inflation and the inflation risk premium. As a result, the nominal rate and the value of the nominal liabilities remain unchanged. From table 2, we observe that this scenario causes a fall of the value of the real liabilities. Scenario 2 shows a fall in nominal interest rates with unchanged real rates. In this scenario, the value of the nominal liabilities increases relative to the current situation, whereas the value of the real liabilities remains unchanged. Scenario 3 shows a fall in real rates combined with a rise in nominal rates. In this scenario, the value of the real and the nominal liabilities move in opposite directions.

Modigliani and Cohn (1979) suggest that investors suffer from money illusion by discounting real cash flows at nominal rates. Cohn, Polk and Vuolteenaho (2005) find evidence confirming the existence of money illusion among investors. It seems less likely that pension fund managers suffer from this explicit form of money illusion. However, it is possible that they suffer from a more subtle form of money illusion, where they do ignore the difference in duration for real and nominal cash flows. Such an investor may try to match the real pension liabilities with nominal assets. In table 3, we consider the implications of the asset allocation strategy for an investor with real liabilities using our example of the pension fund with a real liability. We assume that our pension fund has a funding ratio of 110%, which implies that the value of assets equals 996.30. Next, we consider different asset allocation strategies with varying allocations to nominal and real bonds. In table 3 we present the value of the surplus given the scenarios presented in table 2 for the different asset mixes.

Table 3: The impact of asset allocation on the surplus

Relative weight in		Scenario 1		Scenario 2		Scenario 3	
Nominal bonds	Real bonds	Value of surplus	% change relative to base case	Value of surplus	% change relative to base case	Value of surplus	% change relative to base case
0%	100%	85.16	-6.0%	90.57	0.0%	95.15	5.0%
25%	75%	100.04	10.5%	117.15	29.3%	59.84	-33.9%
50%	50%	114.93	26.9%	143.73	58.7%	24.54	-72.9%
75%	25%	129.82	43.3%	170.30	88.0%	(10.76)	-111.9%
100%	0%	144.70	59.8%	196.88	117.4%	(46.07)	-150.9%

As can be seen in this table, the strategy of investing fully in nominal bonds is the most disastrous, as it presents the largest possible loss equal to –150.9% of initial surplus. The least risky asset mix is that of 100% in real bonds, which has a maximum loss of 6% in scenario 1. Although this analysis is based on a set of rather ad-hoc scenarios, the scenarios themselves are realistic in the sense that they can occur in reality. A perhaps remarkable observation is that the strategy of fully investing in nominal bonds is the most risky strategy. This is remarkable since prior to the 90s of the previous century, many pension funds were actually following this strategy.

Given the different response of real and nominal bonds to changes in the real and nominal interest rates, it is important to capture these differences in a performance measurement framework. In particular, it is necessary to construct benchmark portfolios that account for the difference between real and nominal cash flows.

4. Benchmarks and performance attribution

In this section, we develop a benchmark based on inflation-linked assets. Furthermore, we propose an attribution framework to analyze the performance of the asset manager relative to the benchmark. Our model is based on the concept of matching, and is an adjusted version of Plantinga and Huygen (2001) that was developed for measuring the performance of life-insurance companies. The basis for the benchmark in this model is a strategy of cash flow matching, where a part of the asset portfolio is dedicated to tracking the value of the liability portfolio (the so-called liability-driven asset portfolio) and a part of the asset portfolio is invested in risky assets (the so-called surplus-driven asset portfolio). Since life-insurance companies are dominated by nominal liabilities, it was sufficient to use only one liability-driven asset portfolio. However, for pension funds, which have both nominal and real liabilities, we have to split the liability-driven asset portfolio in two parts, the nominal asset portfolio and the real asset portfolio.

The following balance sheet summarizes the assets and liabilities used in our benchmarks and performance attribution model:

Assets		**Liabilities**	
Surplus assets	A_s	Surplus	S
Nominal assets	A_n	Nominal liabilities	L_n
Real assets	A_r	Real liabilities	L_r

The benchmark for the nominal asset portfolio is a portfolio that consists of nominal zero coupon bonds with the same maturity as the nominal liabilities. The benchmark for the real asset portfolio consists of real zero coupon bonds with a maturity structure similar to that of the liabilities. The benchmark for the surplus-driven assets can be derived from an appropriate market index. For example, if pension fund management decides to invest the risky assets in a worldwide stock portfolio, the MSCI World Index may be an appropriate candidate. The surplus assets provide freedom to pursue active management. For example, the surplus assets can be invested in stocks, real estate or any other asset. However, it is important to maintain the primacy of the liabilities: risk-taking behavior should not endanger the value of the liabilities. If the manager is very active with the liability-driven asset portfolio, then the risk budget for the surplus assets becomes smaller. A risk management framework should be in place that limits the ability of the asset manager to engage in a very risky surplus portfolio[5].

The primary objective of the liability-driven asset portfolio is to match the liability portfolio as closely as possible. As a secondary objective, the asset manager may attempt

[5] See for example, Sharpe, W.F. (2002).

to outguess the market by anticipating movements in stock markets, real interest rates and inflation. In our model, the asset manager can attain this goal with three different instruments. First, the manager can deviate the actual allocations to the nominal and the real asset portfolios from those implied by the benchmark. The benchmark suggests that the allocation should be equal to the market value of the cash flow matched portfolios. The second instrument is the maturity management within the nominal and real asset portfolios: the manager may choose durations different from those of the liabilities. As a result, the surplus return of the pension fund will be subject to interest rate risk. Related to the choice of the maturity structure is the choice of the instruments. For example, pension funds may choose not to buy real zero-coupon bonds, but rely on derivatives or structured products, such as inflation rate swaps that incur some credit risk. The third instrument is the choice of the surplus-driven asset portfolio, which can be freely invested as long as it is not excessively exposed to risk.

The realized surplus return of the pension fund is defined as:

$$s_a S = A_s r_a^s + A_n r_a^n + A_r r_a^r - L_n r_l^n - L_r r_l^r , \tag{5}$$

where s_a is the realized surplus rate of return, r_a^s is the realized return on surplus assets, r_a^n is the realized return on the nominal asset portfolio, r_a^r is the realized return on the real asset portfolio, r_l^n is the realized return on the nominal liabilities, and r_l^r is the realized return on real liabilities. Rearranging the terms results in the following expression:

$$s_a = \frac{A_s}{S} r_a^s + \frac{A_n}{S} r_a^n - \frac{L_n}{S} r_l^n + \frac{A_r}{S} r_a^r - \frac{L_r}{S} r_l^r . \tag{6}$$

Our benchmark is based on perfect cash matching. This implies that the allocation to the three asset classes equals $A_s = S$, $A_n = L_n$, and $A_r = L_r$. . The benchmark return is defined as:

$$s_p = r_p^s + \frac{L_n}{S}\left(r_p^n - r_l^n\right) + \frac{L_r}{S}\left(r_p^r - r_l^r\right), \tag{7}$$

where r_p^n is the return on the portfolio that is cash flow matched with the nominal liabilities and r_p^r is the return on the portfolio that is cash flow matched with the real liabilities. The difference between equation (6) and (7) provides the difference between the return on the actual portfolio and the benchmark. In order to analyze the causes of these differences, we regroup a number of terms. First, we identify the following three allocation mismatches: the surplus allocation mismatch, the nominal allocation mismatch, and the real allocation mismatch. These mismatches refer to deviations in the size of the three portfolios from the benchmark.

The surplus allocation mismatch is defined as:

$$\delta_s = \frac{A_s}{S} - 1, \tag{8}$$

the nominal allocation mismatch is defined as:

$$\delta_n = \frac{A_n}{S} - \frac{L_n}{S}, \tag{9}$$

and the real allocation mismatch is defined as:

$$\delta_r = \frac{A_r}{S} - \frac{L_r}{S} \tag{10}$$

As a result, we are now able to construct the following performance attribution:

$$s_a - s_p = r_a^s - r_p^s + \delta_s r_a^s + \frac{L_n}{S}\left(r_a^n - r_p^n\right) + \delta_n r_a^n + \frac{L_r}{S}\left(r_a^r - r_p^r\right) + \delta_r r_a^r . \tag{11}$$

Equation (11) provides useful information regarding the performance of the pension fund, and we use it as the basis for performance attribution. Summarizing all the components involving δ_s, δ_n, and δ_r results in one component for the allocation mismatches. Consequently, we identify the following four components that determine the excess performance of the pension fund relative to its benchmark:

$$s_a - s_p = \begin{array}{ll} r_a^s - r_p^s & (i) \\ \frac{L_n}{S}\left(r_a^n - r_p^n\right) & (ii) \\ \frac{L_r}{S}\left(r_a^r - r_p^r\right) + & (iii) \\ \delta_s r_a^s + \delta_n r_a^n + \delta_r r_a^r & (iv) \end{array} \tag{12}$$

The first component is the excess return on surplus assets. The second component represents the difference between the actual portfolio of nominal assets and its benchmark. The difference is multiplied by the ratio of nominal assets over surplus. This component corresponds is caused by the maturity mismatch between nominal bonds and liabilities. The third component represents the difference between the actual portfolio of real assts and its benchmark, multiplied by the ratio of real assets over surplus. This component is the result to the duration mismatch between real liabilities and bonds. The fourth component is the sum of the allocation mismatches.

Consider the following example of a pension fund with a nominal obligation of 1,000,000 due in 30 years and a real obligation of 1,000,000 in 30 years. The real obligation is expressed in terms of purchasing power at t=0. The nominal assets are invested in zero coupon bonds yielding a cash flow of 1,050,000 in year 20, and the real assets are invested in zero coupon bonds yielding a cash flow of 150,000 (expressed in terms of purchasing power at t=0) in year 5. In order to value these cash flows, the levels of the real interest rate, the expected inflation and the inflation risk premium are given in table 4.

Table 4: Interest parameters for example

	t=0	t=1
Real interest rate	0.75%	0.40%
Expected inflation	2.00%	3.25%
Inflation risk premium	0.50%	0.50%
Nominal interest rate	3.25%	4.15%

Based on the data in table 4, we calculate the balance sheet of our pension fund at $t = 0$ and $t = 1$. The results are presented in table 5. In order to keep the example simple, we assume that the projected cash flows from the liabilities remain constant. In other words, there are no credit risk events or deviations from the original mortality assumptions. As a result, the return on each of the two liability categories is the same as the return on the cash flow matched benchmark portfolio. The value of the stock portfolio at $t = 1$, is based on an assumed stock return of 2.09%. In this example, we focus on the performance of the existing portfolio of assets and liabilities, and we ignore new pension fund liabilities created during the year. As we can observe from table 5, the surplus of the pension fund decreased considerably, result in a negative surplus return of –76.6%.

Table 5: Example of a pension fund balance sheet

Panel a: Balance sheet at t=0

		Liabilities	
Surplus assets	575,000	Surplus	91,070
Liability-driven portfolio	698,344	Liabilities	1,182,275
real assets	144,499	-real liabilities	799,187
nominal assets	553,845	-nominal liabilities	383,088

Panel b: Balance sheet at t=1

Assets		Liabilities	
Surplus assets	587,000	Surplus	21,329
Liability-driven portfolio	632,536	Liabilities	1,198,207
real assets	147,624	-real liabilities	890,681
nominal assets	484,912	-nominal liabilities	307,525

Panel c: Returns

Assets		Benchmark/liabilities	
Surplus assets	2.09%	Surplus	-76.58%
Liability-driven portfolio	-9.42%	Liabilities	+1.34%
real assets	+2.16%	-real liabilities	+11.45%
nominal assets	-12.45%	-nominal liabilities	-19.72%

From panel c in table 5, we observe that the liabilities have risen in value, whereas the asset portfolios that supposed to have matched the liabilities decreased in values. These results suggest that a considerable mismatch existed between assets and liabilities. In order to attribute the negative surplus return to specific causes, we use the performance attribution proposed in equation (11). We have calculated the leverage ratios as well as the allocation mismatches identified in equation (8) to (10) in the following table:

	Leverage		Allocation mismatch	
Surplus	1		Nominal	+1.88
Nominal liabilities	4.21		Real	-7.19
Real liabilities	8.78		Surplus	+5.31

As a result, we can now easily calculate all the components of the liability-driven performance attribution for our pension fund. The results of this calculation are presented in table 6:

Table 6: Liability-driven performance measurement for a pension fund

		Return
I	Excess performance on surplus assets	0.00%
II	Nominal duration mismatch	30.62%
III	Real duration mismatch	-81.49%
IV	Allocation mismatch	-27.79%
	Surplus return	**-76.58%**

Since we assumed that the surplus-driven assets were invested according to the benchmark, the contribution of the first component equals 0%. The second component has a positive contribution to surplus return, indicating that the decision to have the nominal asset duration shorter than the liability duration was a good decision given the increase in nominal interest rates. On the other hand, the negative return for the third component suggests that the decision to have a lower duration for the real assets than for the liabilities turns out to be disastrous given the fall in real interest rates. The attribution makes clear what the impact of each decision is. In this example, the real duration mismatch had the largest impact on the negative surplus return.

5. Conclusion and discussion

Triggered by bad stock market performance, defined benefit pension plans experienced serious difficulties at the beginning of this new century. In our opinion, the stock market performance contributed only partly to this situation. More important is the poor choice of benchmarks used in risk and performance control. Since pension funds are designated institutions for providing reliable pension to individuals, the reliability of these pensions should be the primary objective of the pension fund. However, in practice, pension funds have to balance the objective of the level and reliability of the pension with that of the costs of the pension. The benchmark in this paper implies a clear choice for the reliability of the future pension claims. This choice does not imply that we ignore the costs for the sponsor of the pension plan. However, we believe that the desire for lowering the costs should be honored by lowering the pension benefits beforehand, rather than by means of a lower probability of being able to service the promised claims. The latter would cause high costs for the beneficiaries afterwards, which incur unexpected wealth losses if asset markets perform badly.

In this paper, we emphasized the importance of making a distinction between nominal and real liabilities for pension funds. The investment strategy of a pension fund should be based on assets that matching the risk characteristics with its liabilities. We propose a portfolio of assets that is cash flow matched with the real liabilities and one matched with the nominal liabilities. In addition, we have a third portfolio, which is the portfolio of surplus assets that can be freely invested. The benchmark portfolio should be based on this strategy. In reality, this strategy may be difficult to attain due to a lack of index-linked assets. Nevertheless, in the near future, the growing supply of inflation-linked products may be able to meet this demand. Furthermore, creating sufficient surplus-assets may help to cushion the risks from unexpected inflation developments.

In section 4, we proposed a performance attribution model based on the cash flow matched benchmark portfolios. This attribution model facilitates the evaluation of the investment performance starting from the characteristics of the liabilities. It enables the user to identify the performance of the most risky decisions, and in particular of the mismatch of the real and nominal duration between assets and liabilities. Given the restriction on the availability of index-linked assets, it is possible to adjust this framework in order to analyze the results from a feasible benchmark.

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