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Application of Liability Driven Investment (LDI) Strategy in Japan — Can it be a solution to bail out defined benefit pension plans?

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Abstract

Liability driven investment (LDI) is a development from surplus-based ALM, which has its origin in research studies of the late 1980s. This paper acknowledges that (i) the utilization of derivatives, (ii) risk budgeting, and (iii) market value-based evaluation of assets, liabilities, and surplus, are characteristics of current LDI. The introduction of LDI would improve the risk-return profiles of pensions and be a very effective countermeasure to mark-to-market accounting in financial statements. In implementing LDI, there are three challenges: (i) the identification of liability cash flows and the establishment of asset portfolios to match such cash flows, (ii) having an internal structure to manage and control derivative transactions and costs involved, and (iii) coordination with plan sponsors as to responsibility for, and control of, LDI strategy.

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Introduction

Liability driven investment (LDI) is an investment strategy that pension and insurance companies have increasingly put into practice in the last two to three years in European countries, such as the UK and the Netherlands, and also in the US.

However, there are different opinions as to what LDI actually is, the effects, feasibility, etc. Thus, section 1 attempts to explain LDI in detail, compare with conventional ALM, and ascertain reasons for its increasing popularity. Section 2 briefly describes the implementation process. In section 3, assuming a typical defined benefit pension scheme, we illustrate an LDI-based portfolio and examine the effects of LDI. In section 4, we position LDI as a countermeasure for increasingly prevalent mark-to-market accounting and explain the challenges in implementing LDI strategy in Japan.

Against the background of mark-to-market accounting rules being increasingly applied to financial accounting, as well as regulatory funding standards, LDI has the potential of managing risks attaching to defined benefit pension plans and becoming a powerful means supporting such plans in overcoming the difficulties of coming years.

1. Pension ALM and LDI—Why LDI now?

(1) What is LDI?

LDI is an investment strategy for managing risk attaching to pension asset portfolios with reference to pension liabilities as a benchmark. When we take only assets into consideration, cash is the risk-free rate, and excess return over cash is obtained by taking risk. Then, we choose an optimal portfolio based on risk and excess return.

In LDI, pension liabilities are taken into consideration. The asset (portfolio)¹ which produces the same cash flow as a pension liability is regarded as a risk-free asset or a risk-free portfolio. Then, in pension plan portfolios, we combine the risk-free asset with a risky asset, such as stocks which carry tracking error from a risk-free asset. Investment strategy comprises managing risk (tracking error) of deviating return from that of risk-free asset that have the same cash flow as the pension liability and expected excess return on top of risk-free return as compensation for taking that mismatching risk (tracking error).

¹ *In fact, the risk-free asset (matching asset) is often a portfolio of various assets—in this paper we use both the singular and plural forms (asset/assets) and similarly liability/liabilities.*

(2) Difference from conventional ALM

Hitherto, asset liability management (ALM) has been used to manage and control the funding surplus of defined benefit pension plans. The core idea of LDI—managing risk (tracking error) and return by regarding an asset (portfolio) with the same cash flow as a pension liability as a risk-free asset—is explained in several research works as early as Sharpe and Tint [1990]. Moreover, Leibowitz [1986a] and [1987a] insisted that the surplus could be kept constant irrespective of interest rate changes by matching cash flow or duration of assets and liabilities. LDI, in that sense, is the same as ALM which Sharpe, Leibowitz, and others put forward 20 years ago. In Japan, pension ALM has already been practiced referring to outstanding research studies, including Omori [2002], and Asano et al. [2003] and [2006].

Is LDI only another version of ALM then? Actually, apart from the name, LDI incorporates three aspects not found in traditional pension ALM. *First*, derivatives, such as swaps and options, are utilized in addition to cash long-term bonds. The purpose of using derivatives is to adjust cash flow and duration of assets to that of liabilities, as discussed later, and to accept market risk in order to improve the risk return profile of the portfolio.

Second, LDI uses risk budgeting methods where two types of risk—active risk over the asset class benchmark and asset class benchmark passive risk from liabilities—are integrated into a single risk management framework. These two methodologies, which neither Sharpe nor Leibowitz took into explicit consideration, have been developed through pension management practice over the last 20 years.

Third, the liability target differs from that of conventional pension ALM. As the work edited by Kobayashi [2004] pointed out, in existing pension ALM practice, the target in asset management is the liability prescribed by the minimum funding requirement which increases by a fixed assumed rate of interest regardless of prevailing market conditions. The impact of changing interest rates is not taken into account. An efficient frontier based on expected risk and returns is drawn and probability distributions of pension asset value of the portfolio on the frontier are compared with the value of the liability target three to five years later. In the end, the portfolio with the lowest probability of shortfall and/or increase in pension contribution is selected.

However, the liability managed under LDI is not that for regulatory purposes but fair value i.e., market value or present value which is the sum of each pension benefit discounted by the market interest rate corresponding to the period from now to benefit payment. If the discount rate changes with the market interest rate, pension liability value will fluctuate. Therefore, expected return of liability is stochastically distributed as in the case of other long-term debt². In LDI, a certain figure is assumed as the correlation coefficient between returns on assets and

² Leibowitz [1987b] defined liability return as (fair value at term-end + pension payment during the term – fair value at beginning of term) / (fair value at beginning of term).

liabilities, and, based on it, probability distributions for the surplus and funding ratio are drawn. A portfolio is selected referring to the result.

(3) Why LDI now?

Although ALM was not really realized as a business practice in the shape Sharpe, Leibowitz, and others advocated, in the past few years LDI has been in the spotlight in developed countries. One major reason is that mark-to-market accounting has gradually attracted attention both in terms of regulatory funding rules and financial accounting standards. Conventionally, both allowed (i) smoothing and delaying the recognition of changes in asset and liability value, (ii) using the single discount rate for any maturity of liability, and (iii) using the average yield of the past several years instead of the spot rate for the discount rate. As a result, asset and liability value revealed on balance sheets diverged from the market.

A new financial regulation (FTK: Financieel toetsingskader) applicable to Dutch insurance and pension business from 2007 marked the beginning of change in the minimum funding regulation, and set the course towards mark-to-market accounting. There, assets and liabilities are measured at fair value. The discount rate for liabilities is the spot rate in the swap market for the maturity corresponding with that of benefit cash flow.

The rules require pension funds to maintain (i) the current funding ratio, and (ii) a funding ratio in the lower 5 percentile of probability distribution one year later at 105% or more. The same kind of solvency regulations for insurance and pension funds were also introduced in Denmark and Sweden.

In the US, the Pension Protection Act 2006 introduced the following steps as minimum funding standards: (i) shortening of the maximum smoothing period for asset and liability evaluation from five to two years, and (ii) calculating liability value using the discount rate estimated from the yield curve for three periods corresponding with liability maturity of 0-five years, 5-20 years, and 20 years.

In the field of financial reporting, Financial Reporting Standard No. 17 (FRS17) of the UK, introduced in 2005, demands that changes in the fair value of pension assets and liabilities, which are called actuarial differences, cannot be smoothed over a long period but must be recognized immediately on financial statements³ for the term when occurring. Statement of Financial Accounting Standards No. 158 (FAS158) of the US adopted from the end of 2006 stipulates that all changes in the fair value of plan assets and liabilities including the difference accrued at the time of accounting standard change and past service liability as well as actuarial differences must be recognized in the statement of comprehensive income and balance sheet at the end of the year when occurring. Furthermore, in the next phase, FASB takes into consideration the proposal of recognizing the foregoing change in the value of pension assets and liabilities on the income statement. It may be inevitable that these moves in the previously

³ *Appropriated for the total recognized profit/loss account and balance sheet.*

mentioned countries will affect and result in changes in Japanese accounting standards in the future.

In addition to the prevalence of derivative transactions such as interest rate swaps, because of the wider adoption of mark-to-market funding and accounting standards, LDI is drawing attention. While several surveys show that only 10-20% of European and British pension funds have introduced the LDI method using swaps, the move to introduce LDI is noteworthy among the leading pension funds⁴.

2. LDI Implementation

(1) Liability cash flow estimate and specification of matching assets

The first step is estimating pension liability (benefit payments) cash flow, which is not only of long maturity but also subject to changes in mortality rate, withdrawal rate, rate of salary increase, etc. Assumptions are determined based on the advice of pension actuaries and cash flow of a benefit estimated.

A matching asset (portfolio) has the same cash flow as the pension liability and is recognized as a risk-free asset in the context of LDI. However, in practice, even if swaps and super long-term bonds are fully utilized, it is difficult to construct a portfolio completely matching pension liability cash flow. The duration⁵ and convexity of assets have to be brought as close as possible to those of the liability by combining several different maturities of swap transactions.

Once assets are matched, actuarial assumptions can change in unpredictable ways. It is thus necessary to constantly modify and adjust the deviation of cash flow between liabilities and matching assets. Making an estimate of liability cash flow and formulating matching assets is one of the difficult problems encountered in implementing LDI⁶.

(2) Construction of investment portfolio

The second step is the construction of a portfolio consisting of matching assets and other asset classes. In this step, as in Sharpe and Tint (mentioned above) or in pension ALM in practice, we may use (i) mean-variance optimization in the surplus framework and (ii) a simulation to check changes in the surplus over multi periods.

The mean-variance framework in the surplus framework quantitatively analyzes the trade-off between surplus risk (standard deviation) and expected surplus returns. While this optimization is easy to understand, there are problems, such as (i) because it is single period

⁴ *ATP of Denmark, ABP and PGGM of the Netherlands, WH Smiths of the UK, etc.*

⁵ *Because the yield curve does not shift in parallel, asset price sensitivity to a change in interest rate of different maturity, often revealed as key rate duration, must be managed.*

⁶ *An increase in pension plan closure/terminations where it is comparatively easy to estimate liability cash flow is one reason why the number of pensions adopting LDI is increasing in the UK.*

optimization, it is very difficult to quantify and reflect changes in the surplus over multi periods where the payment of contribution and benefit affect cash flow, and (ii) changes in the surplus and other variables that do not follow normal distributions cannot be handled in this framework.

In contrast, using the multi period Monte Carlo simulation, we can quantify the probability distribution of changes in plan assets and liabilities, and the transition of the surplus and funding ratio.

After constructing a portfolio, it must continually be rebalanced and adjusted. In addition to changes in asset prices, changes in the liability cash flow estimate and duration must be reflected.

3. Discussion of an LDI-based Portfolio in a Model Pension Plan

Below, we examine the risk-return profile of a typical pension portfolio in Japan and several portfolio models we construct applying LDI. We show them as an example of the just mentioned second step in implementing LDI for Japanese defined benefit pension plans.

(1) Assumptions

First, as a model, we use a typical defined benefit pension scheme in Japan (single employer type) with 5,000 participants and pension assets and liabilities being Y50 billion each (Y10 million per person)⁷.

Furthermore, as a plan sponsor, we assume shareholders' equity is Y100 billion (Y20 million per employee), ordinary income Y15 billion (Y3 million), and net income Y10 billion (Y2 million)⁸.

For this model pension plan, we construct several portfolios using the mean-variance optimization method in the surplus framework, and compare their risk-return profile with each other and also with the current average portfolio. Next, we evaluate the portfolios from the results of multi-period Monte Carlo simulation.

In evaluating the risk-return profile of each portfolio, we use the following measures: expected surplus return and risk (standard deviation of returns), maximum one year loss in the amount of assets and/or surplus under 95% probability (95% VAR), and the probability of seeing a shortfall after one year. We believe the last two factors are comparatively easy for plan sponsor investment committees and the pension plan boards of directors to use.

In addition to the standard case where the funding ratio is 100% [see subsection (2) below],

⁷ According to the Pension Fund Association, the number of participants in the 562 defined benefit pension plans was 2,800,000 (per plan average, 5,000) as of the end of fiscal 2005. The liability amount under the minimum funding requirement was Y22,600 billion (Y8,070,000 per person), accumulated assets Y21,700 billion (Y7,750,000), and funding ratio 96.0%.

⁸ Data for 1,000 listed companies we obtained for the accounting period ended March 2006 indicates that consolidated shareholders' equity per employee is Y21 million, ordinary income Y3.2 million, and net income Y1.8 million.

we examine the case where it is 90% [(4)], and also where the interest rate is expected to rise and the expected return of long-term bonds and pension liabilities is negative [(5)]. In the last two cases we verify the validity of opinions, such as "in underfunded pension funds, LDI is difficult to introduce" and "LDI should not be carried out in a period of rising interest rates".

(2) Standard case

In the standard case, we examine portfolio A1 which represents an average policy asset mix of a defined benefit pension⁹, and six portfolios B1-F1. B1-F1 have the highest expected surplus return with surplus risk of 7.78% which is the risk level of portfolio A1 in the asset only framework.

The investment vehicles available differ in B1-F1. B1 is the case where it is possible to invest in the same six asset classes as A1; C1 where an asset having the same cash flow as the pension liability (matching asset) is included in investment vehicles available; D1 where investment vehicles available are limited to the initial six asset classes but interest rate swaps are available; E1 where both matching assets and interest rate swaps are available; and F1 where in addition to vehicles available in the case of E1, active management (active risk 2% and expected active return 0.1%¹⁰) is added using portable alpha methodology.

Assumptions used for expected return, risk, and the correlation coefficient of each asset and liability to construct portfolios and calculate risk and return are shown in **Exhibit 1**^{11 and 12}).

Exhibit 1 Parameters Used in the Mean-variance Optimization Method

Expected return (%)	Risk (%)		Domestic bonds	Domestic equities	Foreign bonds	Foreign equities	Cash	General accounts	General accounts	Pension liabilities
1.3	4.5	Domestic bonds	1	0.1574	0.3125	0.0187	0.4120	0.4293	0.8749	0.8749
7.1	22.8	Domestic equities	0.1574	1	-0.2201	0.3156	-0.1017	-0.0721	0.1574	0.1574
3.0	11.9	Foreign bonds	0.3125	-0.2201	1	0.4154	-0.1055	-0.0849	0.4028	0.4028
7.0	19.6	Foreign equities	0.0187	0.3156	0.4154	1	-0.0504	0.0138	0.0499	0.0499
0.8	1.8	Cash	0.4120	-0.1017	-0.1055	-0.0504	1	0.7987	0.0423	0.0423
1.0	0.9	General accounts	0.4293	-0.0721	-0.0849	0.0138	0.7987	1	0.1203	0.1203
2.0	9.0	Matching assets	0.8749	0.1574	0.4028	0.0499	0.0423	0.1203	1	1
2.0	9.0	Pension liabilities	0.8749	0.1574	0.4028	0.0499	0.0423	0.1203	1	1

⁹ Average asset mix of the defined benefit pension is based on a survey by the Pension Fund Association. However, instead of the 5% allocation to alternative investments which is classified as "other asset classes" in that survey, we allocate that 5% proportionally to conventional asset classes.

¹⁰ Here, considering the analysis in Asano et al. [2003], we set the information ratio, which is usually set from 0.5 to 1.0, at 0.05, assuming most performance records of the information ratio are achieved by fortune.

¹¹ As for expected return on an asset, we use the average values of the defined benefit pension plans indicated in the Pension Fund Association survey. The expected return of the liability is 2.0%, which we have calculated from a composite index (by Lehman Brothers) of the par coupon yen interest rate swap (equal weighted average of one year to 30 years, duration 12.3 years). Expected return on cash assets is 0.8%, and life insurance general accounts 1.0% as an expected dividend of 0.25% was added to the 0.75% guaranteed income of the contract without cancellation deduction.

¹² We use historical quarterly return data from 1991 and afterwards for the calculation of risk and correlation coefficient except for the correlation coefficient between stocks and domestic bonds for which we use historical quarterly data from 1965 and afterwards.

Exhibit 2 Comparison of Portfolio Profiles in the Standard Case

(The unit for 95% VAR is Y100 million; correlation coefficient is the real number; for everything else, %)

Portfolio	In asset only framework	In surplus framework (LDI method)					
	A1 (Average of DB pension)	A1 (Average of DB pension)	B1	C1	D1	E1	F1 (with active portfolio)
Matching assets:	without	without	without	with	without	with	with
Interest rate swaps:	without	without	without	without	with	with	with
Domestic bonds	32.8	32.8	31.4	0.0	120.1	0.0	0.0
Foreign bonds	11.2	11.2	42.1	13.8	43.8	26.9	26.7
Domestic equities	27.3	27.3	26.5	26.5	30.9	27.5	27.3
Foreign equities	16.6	16.6	0.0	15.4	5.3	13.6	13.5
General accounts	10.4	10.4	0.0	0.0	0.0	32.0	32.5
Matching assets	0.0	0.0	0.0	44.3	0.0	100.0	100.0
Call debts (Cash)	1.7	1.7	0.0	0.0	-100.0	-100.0	-100.0
Total assets	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Expected surplus return	NA	1.98	1.55	2.26	2.64	3.23	3.26
Surplus return risk	NA	9.68	7.78	7.78	7.78	7.78	7.78
95% VAR (Y100 million)	-44.1	-69.7	-56.2	-52.7	-50.8	-47.8	-47.7
Probability of seeing shortfall	30.46	41.90	42.08	38.57	36.74	33.89	33.77
Expected return in asset only framework	3.98	3.98	3.55	4.26	4.64	5.23	5.26
Asset only risks	7.78	7.78	7.05	9.02	10.31	13.55	13.53
Correlation coefficients between portfolio and liabilities	NA	0.343	0.555	0.628	0.684	0.836	0.827

For A1 to F1, asset allocation, expected surplus return and risk, 95% VAR, probability of seeing a shortfall, expected return and risk in asset only framework, and correlation coefficient with pension liabilities are shown in **Exhibit 2**. When portfolio A1 is seen only for assets, expected return is 3.98%, risk (standard deviation) 7.78%¹³, and 95% VAR is Y4,400 million net losses. The sponsoring company must accept the loss of pension funds up to 4.4% of shareholder equity or 44% of current net income.

However, in the surplus framework, the expected surplus return of A1 falls to 1.98% (expected liability return 2.0% is deducted from expected return on assets of 3.98%), and risk increases to 9.68%. 95% VAR is a loss of Y7 billion. Then, referring to portfolios B1-F1, while

¹³ The highest expected return in a portfolio of the same risk as A1 is 4.11%. A1 will be located slightly inside the efficient frontier.

allocation to domestic bonds is high for B1 (31.4%) and D1 (120.1%), in C1 and E1 where matching assets are available, matching assets have a large allocation instead of domestic bonds. Moreover, in D1-F1, allocation to cash shows -100% since the interest rate swap in which notional principal¹⁴ is ¥50 billion (100% of plan assets) is incorporated.

Looking at expected surplus return and risk, portfolio B1 compares almost equally with A1. However, C1 has higher expected return under surplus risk lower than A1, and D1 and E1 have higher expected surplus return under the same surplus risk level as C1. Even if looking at the probability that the plan sees a shortfall, A1 compares equally with B1, and downside risk becomes smaller as it is set to D1 and E1 from C1. 95% VAR comparison has the same order.

Moreover, in F1, as a result of reducing market risk compared with E1 and assigning the risk to active risk¹⁵, the expected return is the highest at 3.26 % under the same surplus risk.

These results suggest that (i) risk level increases when we look at the current portfolio in the surplus framework, and (ii) incorporating matching assets and using swaps have the effect of making a portfolio more efficient. Furthermore, swaps between cash and domestic bonds (D1) have a greater effect in improving portfolio efficiency than incorporating matching assets (C1). In terms of the correlation coefficient between portfolio and pension liabilities, D1 (0.68) is higher than C1 (0.63).

While the total allocation to domestic and foreign stocks is 43.9% in portfolio A1, it is slightly low at 26.5% in B1 and 36.2% in D1, but in C1 and E1, it is 41.9% and 41.1%, respectively, which is almost the same allocation as in A1. If LDI is introduced, the additional room in risk budget generated from controlling interest rate risk can be directed to other market risks including stock market risks. It is a misunderstanding that most plan assets are allocated to domestic bonds in LDI¹⁶.

(3) Verification of multi period effect by simulation

Then, by multi period Monte Carlo simulation, we examine probability distribution of surplus amount for a period of ten years in A1, D1, and E1. We assume the rebalancing of asset allocation at the end of each year disregarding the payment of contributions and benefits.

As shown in **Exhibit 3.1**, for 5 percentile, 50 percentile (median), and 95 percentile values, the surplus is large in order of E1, D1, and A1. In the case of A1 it is especially lower than the other two at 95 percentile value. D1 and E1 are excellent at controlling downside risk¹⁷.

¹⁴ Here, we limit the notional principal of swaps to the same amount as plan assets, taking into consideration possible hypothecation in swap transactions.

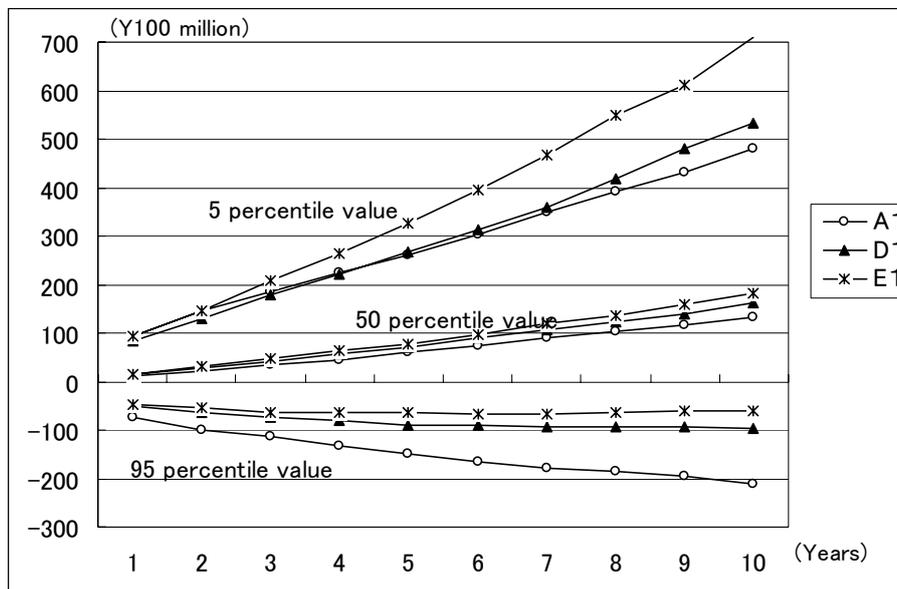
¹⁵ The active portion of F1 is equivalent to 49% of plan assets.

¹⁶ Allocation to domestic and foreign stocks becomes 35% when the correlation of domestic stocks and bonds and pension liabilities is set to zero in E1. In the case where we set expected surplus return at 1.98%, as in A1, allocation to stocks is 24.2%, and 31.7% in the case where we maximized the utility using degree of risk aversion estimated from portfolio A1. As long as we allow for a reasonable degree of risk budget, stocks receive a considerable allocation.

¹⁷ Refer to Chapter 8, Asano et al. [2006] for ALM simulation incorporating interest rate models in an environment of rising interest rates.

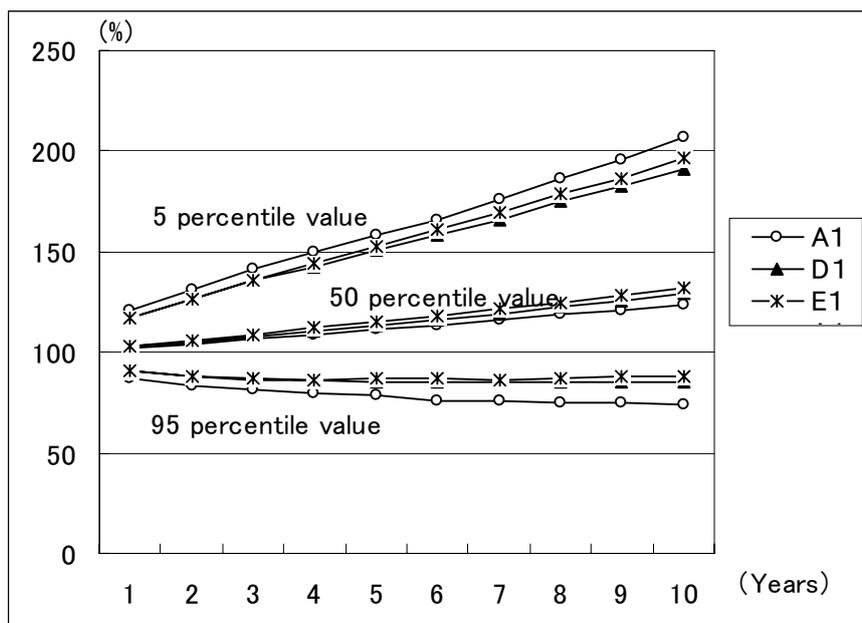
Exhibit 3 Portfolio Comparison by Monte Carlo Simulation (standard case)

3.1 Distribution of Surplus



However, when looking at the funding ratio in these three portfolios (**Exhibit 3.2**), the 95 percentile value shows downside risk and the 50 percentile value is high in the order of E1, D1, and A1. However, the 5 percentile value of A1 is the highest. This may be a case where the expected return on liabilities is negative, and correlation coefficients for assets and liabilities are low. The funding ratio increases where the return on assets is positive and return on liabilities is not so high.

3.2 Distribution of Funding Ratio



(4) Case of underfunding

The average funding ratio to minimum funding liability in defined benefit pension plans was 96% at the end of fiscal 2005. Thus, quite a few pension funds saw a shortfall. We compare portfolios A2-E2 with the same conditions and restrictions as standard cases (A1-E1) except that the funding ratio is 90% since Y45 billion in pension assets is to cover pension liabilities of Y50 billion (see **Exhibit 4**).

In portfolio A2, expected surplus return is 1.58%, risk is 9.33%, and 95% VAR after one year is a loss of Y6,900 million. The Y5 billion shortfall increases to Y11,900 million. As in the standard case, looking at A2-E2, A2 and B2 are on par in terms of performance. In C2, D2, and E2, expected surplus return becomes higher at the same risk level. The finding that use of swaps and availability of matching assets improves the risk-return profile does not change. However, when we compare B2-E2 with B1-E1—portfolios under the same conditions as standard cases—expected surplus return under the same surplus risk is lower by 0.2%, and the 95% VAR loss amount is larger by Y60 million at Y160 million. A surplus efficient frontier in this case is positioned lower than that in the standard case.

Thus, in case of underfunding, expected surplus return is lower than the case of full funding even at the same level of risk. In order to raise the expected funding level, more risk must be taken.

Exhibit 4 Comparison of Portfolio Profiles in the Case of 90% Funding Ratio

(The unit for 95% VAR is Y100 million; for correlation coefficient, the real number; for everything else, %)

Portfolio	A2 (Average of DB pension)				
	B2	C2	D2	E2	
Matching assets	without	without	with	without	with
Interest rate swaps	without	without	without	with	with
Domestic bonds	32.8	27.8	0.0	111.8	8.1
Foreign bonds	11.2	44.6	11.8	49.4	33.5
Domestic stocks	27.3	27.7	27.7	34.3	31.8
Foreign stocks	16.6	0.0	16.8	4.5	14.0
General accounts	10.4	0.0	0.0	0.0	12.6
Matching assets	0.0	0.0	43.6	0.0	100.0
Call debts (Cash)	1.7	0.0	0.0	-100.0	-100.0
Total assets	100	100	100	100	100
Expected surplus return	1.58	1.30	1.94	2.40	3.11
Surplus return risk	9.33	7.78	7.78	7.78	7.78
95% VAR (Y100 million)	-68.8	-57.5	-54.3	-52.0	-48.4
Probability of seeing shortfall	81.65	86.84	85.00	83.58	81.22
Expected return in asset only framework	3.98	3.66	4.37	4.89	5.68
Asset only risks	7.78	7.31	9.26	10.84	14.68
Correlation coefficients between portfolio and liabilities	0.343	0.540	0.601	0.659	0.820

(5) The case of rising interest rates¹⁸

Next, we examine the case of rising interest rates. As of end-March 2007, the yield on 6-year (the level of the Nomura Bond Performance Index) bonds was 1.3% and that on 12-year bonds (the level of Lehman Brothers yen swap rate composite index) 2.0%. We assumed both would rise in parallel by 0.3% every year until they reach 2.8% and 3.5%, respectively, after five years. In this case, annual average return on the former would be 0.4%, and the latter -0.2%¹⁸. We set the expected return on domestic bonds at 0.4%, and on the matching asset at -0.2%. Then, we create portfolios A3-E3 under the same conditions as the standard case (**Exhibit 5**).

¹⁸ The sum of coupon income and capital loss occasioned by the regular rise in market yield.

Exhibit 5 Comparison of Portfolio Profiles in the Case of Rising Interest Rates.

(The unit for 95% VAR is Y100 million; for correlation coefficient, the real number; for everything else, %)

Portfolio	A3				
	(Average of DB pension)	B3	C3	D3	E3
Matching assets	without	without	with	without	with
Interest rate swaps	without	without	without	with	with
Domestic bonds	32.8	29.2	0.0	72.5	0.0
Foreign bonds	11.2	45.3	47.0	52.1	50.9
Domestic stocks	27.3	25.4	31.2	30.7	33.3
Foreign stocks	16.6	0.0	0.2	0.0	1.6
General accounts	10.4	0.0	0.0	44.7	14.1
Matching assets	0.0	0.0	21.6	0.0	38.6
Call debts (Cash)	1.7	0.0	0.0	-100.0	-38.6
Total assets	100	100	100	100	100
Expected surplus return	3.89	3.48	3.80	3.88	3.96
Surplus return risk	9.68	7.78	7.78	7.78	7.78
95% VAR (Y100 million)	-60.2	-46.6	-45.0	-44.6	-44.2
Probability of seeing shortfall	34.41	32.72	31.27	30.90	30.53
Expected return in asset only framework	3.98	3.66	4.37	4.89	5.68
Asset only risks	7.78	7.31	9.26	10.84	14.68
Correlation coefficients between portfolio and liabilities	0.343	0.557	0.609	0.637	0.682

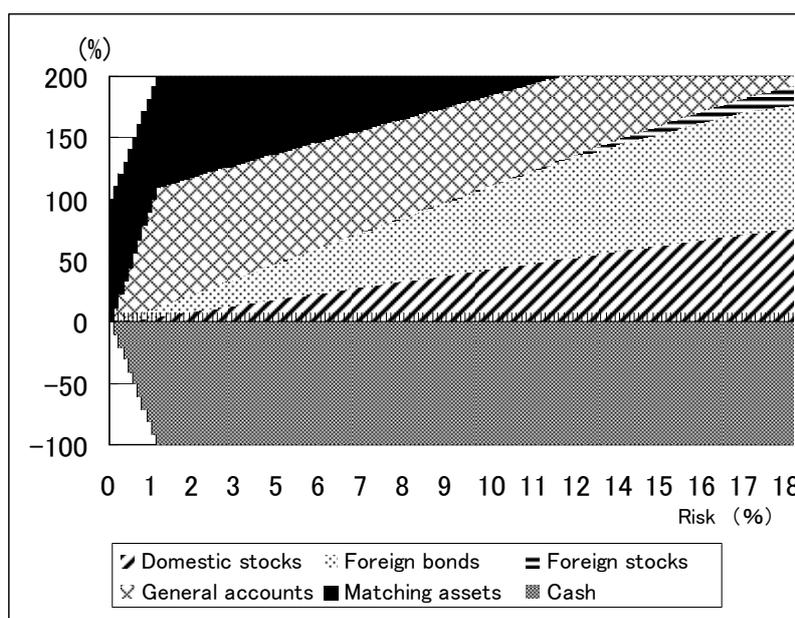
There are three findings to point out. First, the level of expected surplus return for every portfolio is higher by from 0.7 to 1.9% than their counterparts in the standard case. One reason is that return on pension liabilities is -0.2% and it contributes positively to the surplus. As the interest rate level increases, negative expected return on liabilities contributes to an increase in the expected return on the surplus.

Second, the expected surplus return of B3 is lower than that of current portfolio A3, and that of A3 is the same level with those in C3-E3. Unlike the standard case, A3 is no lower than others. However, the risk in C3-E3 is 1.9% lower than in A3. The fact that the availability of

matching assets and adoption of swap transactions enable us to make a portfolio with a risk-return profile superior to A3 remains to be true as in the standard case.

Third, in C3 and E3, although expected return is negative, matching assets have 20% or more allocation. Looking at the optimal asset allocation by surplus risk level in **Exhibit 6**, matching assets account for 100% at the zero risk level although allocation decreases gradually as risk level increases. Still, matching assets have a 50% allocation in the optimal portfolio at 6% risk level. Allocation falls to zero only when risk level reaches 12%. Expected surplus return in this case is 6.2%.

Exhibit 6 Breakdown of Optimal Asset Allocation by Surplus Risk Level



Note: Negative 100% allocation of cash combined with 200% total assets shows that the swap which pays cash interest rate is conducted assuming 100% of assets as notional principal. In addition, the allocation to domestic bonds is always zero.

Moreover, expected return of the matching asset is negative. However, in a surplus framework, it is the risk-free asset. In order to control risk within an acceptable range, the allocation to matching assets has a negligible effect¹⁹.

As mentioned, the current portfolio is not necessarily the best portfolio in a surplus framework even where interest rates rise and the expected liability return is negative. The risk-return profile can be improved by investment in matching assets and/or utilizing a swap²⁰.

¹⁹ The increase in covariance of assets and liabilities reduces surplus risk. Considering the quadratic utility function, if an increase in utility through risk reduction compensates for utility loss caused by the lower expected return, it would be better to invest in matching assets with negative expected return. Sharpe and Tint [1990] converts utility increases through risk reduction into a marginal increase in return and calls it 'liability hedging credit'.

²⁰ When the interest rate goes up at the same rate every year for five years after the interest rates on 6- and 12-year domestic bonds are 2.3% and 2.6%, respectively, which is suggested from forward market rates, annual return on them will be about 0.7% each. In the case where we set the expected return on

(6) Summary

As we have seen above, portfolio construction and selection pursuant to LDI methodology can improve risk-return profile in a surplus framework. When matching assets and interest swap transactions are available, the effect is notable, but limited when neither can be used as in the case of portfolio B. In particular, an interest rate swap raises the correlation coefficient between pension assets and liabilities, and can improve the portfolio risk-return profile²¹.

LDI has the effect of improving the risk-return profile, even when the price fluctuation of pension assets and pension liabilities is smoothed as under current accounting rules²², the funding ratio is below 100%, and the expected return on liabilities and matching portfolio become negative in an environment of rising interest rates.

Of course, the assumed parameters for risk, return, and correlation coefficient affect the validity of the foregoing results. However, we consider the fact that we can examine the risk-return profile of a portfolio as an advantage of LDI introduction.

4. Conclusion—Response to change in accounting standards and implementation challenges in Japan

As mentioned in section 1, mark-to-market accounting rules which require changes in the value of plan assets and liabilities to be recorded on financial statements immediately in the fiscal period concerned are spreading internationally as seen in the case of US FAS158. However, there is criticism that this mark-to-market accounting rule will become an obstacle for the long-term management of defined benefit pension plans. If this type of accounting rule is also introduced in Japan, concern that pension plans will have to be managed myopically will intensify.

However, LDI, which manages risk and return of the surplus over a time horizon of one to five years, will act as a measure against the spread of mark-to-market accounting and go a long way to maintaining defined benefit pension plans²³. For example, even if price changes in plan assets and liabilities are recorded promptly on income statements for the accounting period concerned as might be proposed in the next phase of FAS158 discussion, by controlling 95%

domestic bonds and matching asset (pension liability) at this 0.7%, asset allocation and the risk return profile of optimal portfolios are approximately in the middle of those in the standard case and in the case of Section 3(5).

²¹ *If we implement interest swap transactions, cash allocation will be -100%. Thus, interest rate swaps have the effect of lengthening the duration of the asset side, which, as we see from the other side of the coin, is the very effect of shortening liability duration as in the case of a short-term loan. In either way, we can raise the correlation coefficient between assets and liabilities.*

²² *In order to verify the effect of LDI when smoothing is applied to a price change in assets and liabilities we take the average of the previous five-year surplus at the end of the 5th through 10th year of each simulation path, and analyze probability distribution. As a result, in all distribution percentiles, the surplus is high, in the order of E1, D1, and A1, and we confirmed that D1 and E1 are superior to A1, especially in controlling lower risk portions as in the case without a smoothing rule.*

²³ *Waring and Siegel [2007] imply the same effect in US defined benefit plans.*

VAR as reviewed in section 3, we can manage the maximum estimated loss (earnings at risk) on the income statement for a period along with the estimated loss of surplus.

Moreover, even when we have to smooth and record the price changes in pension assets and liabilities over several periods as under current financial accounting standards, the introduction of LDI has the effect of easier control of the lower portions in the surplus and funding ratio. If we succeed in reducing the volatility of the surplus marked to market every year, risk (volatility) attaching to the smoothed surplus will naturally also become smaller. In reality, we must pay attention both to pension benefit obligations (PBOs) in financial statements and the liabilities prescribed under minimum funding requirements and their relation with asset prices. That said, if the surplus over the liabilities marked to market is secured, in the long run we can also achieve a surplus over liabilities not completely marked to market in financial and regulatory accounting.

However, in the implementation of LDI in Japan, we face three challenges.

The first is predicting pension liability cash flow and the construction of matching assets (portfolio). Cash flow of a liability changes depending on rate of salary increase and inflation rate in addition to mortality and withdrawal rates. However, in LDI, even if we can manage interest rate risks and those related to the financial market, it is almost impossible to hedge the risk of actuarial assumptions, except for inflation risk²⁴.

Therefore, the perfect construction of matching assets is impossible. In practice, we have no other choice but to manage and quantify the risks stemming from actuarial assumptions and tracking error in cash flow between liabilities and matching assets²⁵.

The same holds true also for a cash balance or hybrid pension plan. In the case of a cash balance plan, duration of the liability is shorter than that in a conventional defined benefit pension plan. It will be easier to equalize the duration of assets and liabilities once benefit cash flow is defined. However, interest rate credit in the cash balance plan, which is based on the historical average, such as the past five-year average of ten-year government bond yield, is not completely connected with market interest rates. Further, usually a floor and a cap are set for interest rate credit. These facts make it very difficult to estimate and define liability cash flow in cash balance plans. In order to put LDI into practice, we will be forced to generate many interest rate paths by simulation incorporating interest rate models, and grasp and manage tracking error between cash flows of liabilities and the next-best matching portfolio.

The second challenge is the implementation of derivative transactions, such as interest swaps, and related cost management. With swaps, in order to manage credit risks of counterparties in accordance with the ISDA master contract, offering collateral is required to

²⁴ *We can use inflation-linked-bonds and inflation swaps as means of inflation hedging. Although longevity bonds, etc., can be tried as a means for hedging mortality, their usage is still very scarce.*

²⁵ *However, risk attaching to actuarial assumptions is unavoidable in the management of pensions regardless of whether LDI is implemented or not. Actuarial risk is not a reason for negating the effect of LDI.*

complement each counterparty's credit ability. However, the managements of most pension funds have no experience of such transactions and it is virtually impossible for them to prepare for such transactions.

There are two ways for pension funds to circumvent this problem. One is to enjoy the LDI effect, such as prolonged duration, through investment in funds which investment companies provide and incorporate swap transactions. The other is that the finance sections of plan sponsors experienced in derivative transactions are directly engaged in derivative transactions, as will be mentioned later. Also, some point out the high cost of derivative transactions as one factor why the ratio of pension funds adopting LDI is still only 10-20% in Europe. Currently, the notional principal of contracts outstanding in the Japanese yen interest rate swap market is more than Y3,600 trillion. Moreover, in swap transaction of about Y10-20 billion size and of standard periods, such as 20 years, 30 years, the bid-offer spread is as low as 0.5-1.0bp²⁶.

On the other hand, in B1 to D1 and C1 to E1 in the standard case described in section 3, expected surplus return improves by about 100bps through using swap transactions. In such cases, even if several basis points of cost are required for swap transactions, and 10-20bps for constructing the fund, it is evident that the advantage of swaps far exceeds those costs. However, in an environment of rising interest rates, we may face a slightly different evaluation.

The third challenge for LDI implementation is the authority and responsibility for introduction. Plan sponsor consolidated financial statements cover the assets and liabilities of not only all pension plans but also of lump-sum unfunded retirement benefit plans and of retirement benefit trusts together. Therefore, if we want to implement LDI in order to cope with the prevalence of mark-to-market accounting, it is desirable to take into account, and manage, the assets and liabilities of all of these plans. From this perspective, LDI for individual pension funds should be consistent with LDI financial management at whole plan sponsor. On the other hand, the administrator of individual funds bears responsibility as a fiduciary and must be loyal to the benefits accruing to, and interests of, plan participants. It will be necessary to adjust and make fiduciary responsibility and financial interests of the plan sponsor consistent.

Finally, in effecting LDI, pension funds in the UK, etc., are said to be asking investment management companies to provide matching assets with pension liabilities. Specifically, pension funds demand the portfolio completely matching the liability or the combination of fixed income funds of some specific duration utilizing super long-term bonds.

This movement suggests that, in the future, vehicles investment management companies provide will be split into (i) low fee passive funds, (ii) high fee active funds to obtain alpha returns, and (iii) matching assets coordinated with cash flow and duration of pension plan liabilities.

²⁶ *Lehman Brothers Securities [2006], etc.*

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