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Managing Capital Market Risk for Retirement

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Managing Capital Market Risk for Retirement

Abstract

We offer an overview of solutions available to pension plans to manage capital market risk in order to meet their obligations. We outline the main drivers behind the evolution of asset-liability management (ALM) for pension plans and the emergence of liability-driven investment (LDI) in the last decade. We look at some of the most popular pension de-risking tools and at recent innovations prompted by the Global Financial Crisis. We offer examples based on the rise of cross-asset correlation, the use of hybrid products to mitigate tail risk, and the increasing relevance of counterparty risk mitigation tools such as collateralization. We conclude by outlining some of the main challenges ahead, including developments in pension regulation, centralized clearing of over-the-counter (OTC) instruments, and risk taking incentives in delegated asset management for long term retirement obligations.

Keywords

pension liabilities, liability-driven investment, cross-asset correlation, collateralization, pension buyouts, over-the-counter OTC instruments

Disciplines

Economics

Comments

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Recreating Sustainable Retirement

Resilience, Solvency, and Tail Risk

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Managing Capital Market Risk for Retirement

Enrico Biffis and Robert Kosowski

The Emergence of Liability-driven Investment

Liabilities of corporate and public defined benefit (DB) pension plans have reached unprecedented levels in the last decade, due to increases in life expectancy and underperformance of the assets backing the promises. Pension trustees have addressed the deterioration of funding levels in different ways, working both on the asset and liability sides. On the liability side, there have been closures of schemes to new members as well as to new accruals, in order to cap liabilities. On the asset side, there has been a stronger focus on asset liability management (ALM), which has translated into 'de-risking' strategies tilting asset allocations away from equities and toward liability-driven investment (LDI).

LDI differs from the simple approach to asset management which aims to maximize the return of a portfolio for a given level of portfolio risk (volatility) without taking liabilities explicitly into account. In fact, LDI is a strategy based on the cash flows needed to fund future liabilities. It can be applied to both DB and defined contribution (DC) pension plans. In the latter, investment decisions and risk rest with the employee; the plan's liability is employee-specific. In the former, pension plan sponsors, with the assistance of actuaries, forecast future anticipated cash payouts to pensioners over their expected lifetimes. From the perspective of a DB plan sponsor, risk entails two main components: investment risk and liability risk, the latter stemming from the stochastic value of pension liabilities. A pension plan's funded status can change due to a change in liabilities, even if investment risk is carefully managed. Although the notion of LDI is not new (there are references to it by U.K. actuaries going back to the 1930s), its adoption among pension plans has only recently become more widespread (Kessler 2014).

The ALM problem faced by a DB pension plan can be represented by a complex dynamic optimization problem. For simplicity, some academic studies abstract from the dynamic nature of the problem and use surplus optimization as a method to reflect the presence of liabilities and its effect on optimal portfolio choice (e.g. Sharpe and Tint 1990; Ezra 1991; Leibowitz et al. 1992; Nijman and Swinkels 2008). These works treat fund liabilities as a state variable and specify an objective function of assets relative to liabilities. The objective function takes into account the correlation between assets and liabilities in determining the optimal portfolio allocation. Surplus at each time t is defined as $S_t(k) = A_t\tilde{k} - L_t$, where A_t denotes the value of the assets at time t and L_t the value of the liabilities, whereas the parameter k measures the importance that the fund management attaches to the value of the liabilities. The return on the fund surplus can be then be defined as $R_t^s(k) = R_t^A - kR_t^L$, where $R_t^s(k)$, R_t^A, and R_t^L are the return on the surplus, the assets, and the liabilities, respectively, and $k = \tilde{k}L_{t-1/At-1}$ (e.g. Sharpe and Tint 1990).

If we assume that the pension fund manager has a mean-variance utility function with risk aversion coefficient γ in the return on surplus, we can derive a closed form solution for the optimal asset allocation. For example, Nijman and Swinkels (2008) use this framework to study whether the risk of investment portfolios of pension schemes investing in traditional asset classes can be reduced by non-traditional investment opportunities such as commodities. They find that the benefits for pension plans with inflation-indexed liabilities are substantial, but they are not large for those with nominal liabilities.

Dynamic ALM

One caveat to this simple static surplus return optimization framework is that it captures only time-varying asset allocation as a result of a repeated application of the static framework. In practice, however, pension asset allocation can be expected to change over time, as market conditions change and/or the plan matures. Over time, assets may be moved away from the return-seeking component of the portfolio and placed into the liability-hedging component. A pension plan sponsor may, for example, decide to take on more risk when a plan is underfunded, to generate a higher return in the hope that the funding status improves. But once a plan's ratio of assets to liabilities (that is, the funded status or funding ratio) reaches a comfortable enough level, sponsors often investigate the possibility of closing or terminating the plan in an effort to remove risk to the plan sponsor; see the discussion of pension buyouts below.

A more general approach to the pension manager's utility function was developed by Rudolf and Ziemba (2004).[1] They do so using a portfolio selection model for an investment company seeking to maximize the intertemporal expected utility of the surplus of assets net of liabilities. They show that the optimal portfolio consists of investors holding a combination of four portfolios: the market portfolio, a hedge portfolio for the relevant state variables, a hedge portfolio for the liabilities, and the riskless asset. In contrast to Merton's (1973) result in the asset-only case, the liability hedge is independent of preferences and depends only on the plan's funding ratio. Demand for the state variable hedge and the market portfolio depends on the investor's preferences. Detemple and Rindisbacher (2008) extend Rudolf and Ziemba (2004) by (a) allowing the factors in the model to follow a more general diffusion process, and (b) defining preferences over intermediate cash flows, instead of the surplus.[2]

The Spread of LDI

LDI has spread widely in recent years. The SEI Pension Management Research Panel (SEI 2012) has conducted an annual poll of corporate pension plans since 2007; in 2012, this poll was completed by 125 pension plans from the United States, Canada, the United Kingdom, and the Netherlands. Figure 2.1 shows that since the poll's inception, LDI more than tripled in use, from 20 percent in 2007 to 63 percent in 2011. The use of LDI dipped to 57 percent in 2012, probably as a result of low funding ratios and exceptional market conditions shaped by quantitative easing.

Of those organizations not utilizing an LDI strategy in 2012, 20 percent said they planned to implement one by the end of 2013. The portion of assets invested in LDI has also increased over time, as Figure 2.2 shows.

Of those plans using LDI in 2012, over half (52 percent) continued to invest more than 40 percent of their portfolio in an LDI strategy; only 11 percent of plans invested less than 20 percent. In other words, as a plan's funding status improves, a greater portion of its portfolio tends to be invested in LDI. It is instructive to see how pension sponsors and trustees define LDI. According to the SEI (2012) poll, most defined LDI in one of two ways: 'matching duration of assets to duration of liabilities' or 'a portfolio designed to be risk managed with respect to liabilities' (see Table 2.1).

Moreover, as shown in Table 2.2, most respondents to the SEI Global LDI Poll describe control of the year-to-year volatility of the funded status as the main goal of LDI.

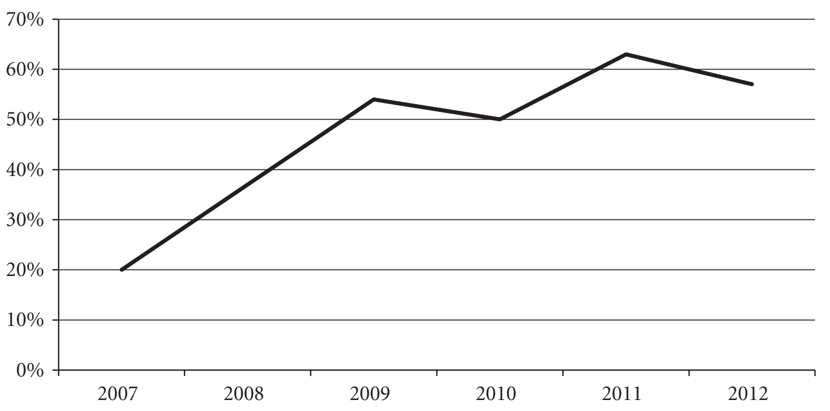

Figure 2.1. Percentage of funds adopting LDI strategies.

Source: SEI (2012).

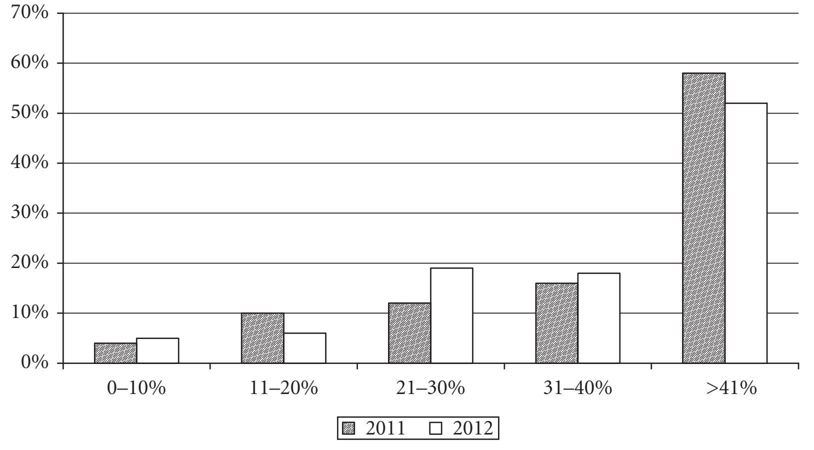

Figure 2.2. Percentage of funds that use LDI strategy.

Notes: This figure shows the portion of the portfolio invested in LDI among the funds that employ LDI. The percentages are shown for 2011 and 2012 as reported in the SEI 2012 poll.

Source: SEI (2012).

Table 2.1 Definition of LDI according to respondents (percent)

Definition of LDI	2007	2008	2009	2010	2011	2012
Matching duration of assets to duration of liabilities	41	30	40	30	46	39
A portfolio designed to be risk-managed with respect to liabilities	38	34	32	39	24	31
Consideration of liability poll and/or costs in setting asset allocations	12	14	7	12	5	11
Immunizing the plan's liabilities with fixed-income securities	2	6	5	7	12	8
Forcing asset performance to mimic liability performance	4	6	8	3	9	7
Use of derivative instruments such as interest-rate swaps	1	1	1	4	2	2
Use of asset classes with reduced volatility	1	9	7	5	2	2

Note: This shows how SEI poll respondents defined what LDI meant to them.
Source: SEI 6th Annual Global LDI Poll (SEI 2012).

Table 2.2 Goals of LDI (percent)

Goals of LDI	2007	2008	2009	2010	2011	2012
Control of year-to-year volatility of funded status	79	79	90	46	78	80
Control contribution and/or pension expense	46	45	51	43	46	53
Minimize/maximize impact on corporate liquidity/cash flow	31	30	35	23	41	30
Improve funding levels	19	14	24	28	26	30
Progress plan toward termination or buyout	8	8	13	20	15	26
Avoid the minimum funding liability	14	13	9	7	5	6

Note: This shows how SEI poll respondents described the goals of LDI.
Source: SEI 6th Annual Global LDI Poll (SEI 2012).

Pension De-risking

Next we provide an overview of some common tools used in LDI and recent innovations in pension de-risking solutions.

Interest-rate and Inflation-linked Derivatives

It is well known that the average duration of pension liabilities is very long and quite difficult to match with standard fixed-income instruments. According to J.P. Morgan (2006), for example, the average duration gap of European pension plans exceeded 13 years in 2006, with an average liability duration of 21 years, and an average duration of fixed-income portfolios falling short of eight years. These figures give an idea of the challenges faced by ALM strategies relying on standard duration gap analysis or interest-rate immunization. In countries where pension regulation has become more transparent and risk-based, notably the U.K. and the Netherlands, pension plans have made structural changes in asset allocation, gearing their portfolios toward liability matching by relying on interest-rate derivatives and hedging programs structured by investment banks and asset managers. The most common products include interest-rate swaps, forward-starting swaps, and 'swaptions' (i.e. options giving the right but not the obligation to enter a swap at a future date). These instruments represent a cheaper and more flexible alternative to bonds, as the latter are in limited supply at the long end of the yield curve, and in any case would typically fall short of the duration target that pension plans favor. Dynamic strategies in fixed-income derivatives also provide a natural way to take advantage of movements in the yield curve that may allow the hedger to lock in a higher funding ratio as a result of the valuation basis used in marking to market the liabilities. Moreover, the format of fixed-income derivatives provides a natural template to address the exposure to other sources of risk, such as inflation and other forms of indexation of pension payments. For example, in recent years, inflation swaps, inflation caps and floors, and related instruments have experienced a dramatic surge in popularity due to LDI programs. The market in these instruments is now quite liquid, provides an efficient alternative to inflation-linked treasuries, and can be used to gauge more precisely the market value of pension liabilities.

Pension Buyouts and Buy-ins

The most direct way for a sponsor to reduce its exposure to pension risk is to transfer part of its pension liabilities to a counterparty.[3] The transfer may take several forms:

- A *pension buyout*, in the case where the original employer's covenant is ended and the counterparty is another principal employer, meaning that all the liabilities of the pension plan, together with the responsibility to meet them, are transferred to another institution.
- A *pension buy-in*, in the case where the counterparty is a life insurer or reinsurer. The transaction essentially entails the purchase of bulk-annuities to insure some or all the liabilities while retaining responsibility for them.

An active pension buyout market developed in the U.K. beginning in 2006, enjoying significant growth and attracting the participation of major players in financial markets (LCP 2012). As a stylized example of pension buyout, consider the case of a DB plan with assets A and liabilities L, valued on an 'ongoing basis' by the plan actuary. When the plan's assets are insufficient to cover the liabilities (i.e. $A<L$), the company recognizes a deficit of $L-A$. If $A>L$ instead, the company's plan has a surplus of $A-L$. Life insurers are usually required to value liabilities under more prudent assumptions than pension plans (regarding future mortality improvements, inflation rates, and market yields), resulting in a larger valuation of the liabilities L'. This increases reported deficits or reduces reported surpluses when a company approaches an insurer for transfer of its pension assets and liabilities. In the case of a deficit, a company borrows the amount $max(L'-A,0)$ and pays it to an insurer to buy out its pension assets and liabilities. The transaction allows the employer to offload the pension liabilities from its balance sheet. This means that the volatility of assets and liabilities associated with the pension plan accounts, the payment of management fees on the plan's assets, and any levies charged for members' protection insurance can be avoided (Coughlan 2014; Kessler 2014). If buyout costs are financed by borrowing, a regular loan replaces pension assets and liabilities on the balance sheet. From the point of view of the plan members, the pensions are secured in full—subject, of course, to the solvency of the life insurer.

Other alternatives exist in addition to the full buyout transactions. *Partial buyouts/ins* may take different forms, and involve the transfer of liabilities originating from a subgroup of members (e.g. deferred pensions, pensions in payment, etc.) or payable over a limited time-horizon (e.g. liabilities above ten years' maturity). Another variation is represented by *synthetic buy-ins* (or do-it-yourself buy-ins), whereby the pension plan enters a series of swap contracts to hedge longevity, investment, and inflation risks, so that the overall effect is similar to a traditional buy-in (Biffis and Blake 2010*b*; LCP 2012). The fixed payments of the swaps are financed by using the income from the pension plan assets, which are retained by the hedger as collateral and hence reduce its exposure to counterparty risk.

Longevity Swaps

Longevity swaps represent a recent innovation relative to traditional buyouts and buy-ins. They are agreements between two parties to exchange fixed payments against variable payments linked to the number of survivors in a reference population. They are used by pension plans to hedge longevity risk: that is, the exposure to the systematic risk of mortality improvements, which cannot be mitigated by pooling together large numbers of lives. The non-financial nature of the exposure to longevity risk is only apparent: the number of active members or pensioners alive at each point in time acts as a multiplier for the financial exposure associated with (current and future) payments to the representative member of a cohort of active or retired individuals. In the language of derivatives, longevity risk introduces a 'quanto' component in pension liabilities,[4] which can dramatically undermine LDI programs based on average notional exposures, particularly if the latter are based on outdated mortality projections.

To date, longevity swaps transactions have mainly involved pension funds and annuity providers wanting to hedge their exposure to longevity risk without having to bear any basis risk (i.e. the risk of mismatch between the hedger's exposure and the reference population on which the hedging instrument is written). The variable payments in such longevity swaps are designed to match precisely the mortality experience of each individual hedger: hence the name *bespoke longevity swaps* (Biffis and Blake 2010*b*; LCP 2012). This is essentially a form of longevity risk insurance, similar to annuity reinsurance in reinsurance markets. A fundamental difference from other forms of reinsurance, however, is that longevity swaps are typically collateralized, whereas typical (re)insurance transactions are not (Biffis et al. 2012*a*). The main reason is that longevity swaps are often part of a wider de-risking strategy involving other collateralized instruments (interest-rate and inflation swaps, for example); additionally, pension plans have been increasingly concerned with counterparty risk in the wake of the subprime crisis (as discussed further on in the chapter).[5]

Financial Innovation in the Wake of the Global Financial Crisis

The subprime crisis has accelerated the deterioration of DB plans' funding levels. Pension sponsors and trustees have addressed the downturn by working on both the liability and the asset sides. To cap liabilities, there have been a number of closures of schemes to new members, as well as to new accruals. According to Hewitt Associates, 'more than half of all [private-sector] employers surveyed at the start of [2009] were considering closing their final salary pension schemes to existing members, effectively freezing retirement benefits at today's levels' (Cohen 2009). Even if liabilities are locked in once a DB plan is closed, there still remains the problem of meeting the pension payments as they fall due, which has led to keen interest in the U.K. pension buyout market experience on the part of pension sponsors the world over. On the asset side, there has been a stronger focus on LDI programs. The interest in de-risking strategies has extended beyond jurisdictions traditionally more active in LDI (such as the U.K., the Netherlands, and Scandinavian countries), and has materialized in large transactions taking place, for example, in North America.

In terms of innovation in de-risking solutions, some of the most important developments involve a stronger focus on tail-risk hedging, contagion, and cross-asset correlation, as well as counterparty risk management.

Tail-risk and Cross-asset Correlation

The secular increase in cross-asset correlation (due to the integration of global financial markets and the deployment of alpha-extraction strategies across asset classes) was taken to a new level by the macro uncertainty resulting from the subprime crisis. The risk-on/off trading style, whereby portfolio risk is adjusted up or down depending on macro-economic uncertainty, has exacerbated the co-movement of different markets and strengthened the view that tail risk can be effectively proxied by measures of correlation or contagion. This has boosted the structuring of tail hedges relying on cross-asset derivatives (also called hybrid products)—in other words, instruments whose payoff is contingent on the price of more than one asset class. As an example, we discuss the stock-bond correlation swaps used in some LDI programs.

Case Study: Stock–bond Correlation Swaps[6]

To illustrate tail-risk hedging based on hybrid products, consider the case of stock-bond correlation swaps. These are instruments paying the difference between a fixed rate agreed at inception (the swap rate) and the realized correlation between the changes in a stock market index and the changes in a bond yield or interest-rate swap rate.

Pension funds are natural candidates for entering a payer correlation swap (they pay fixed and receive the floating realized correlation), as they are net long stocks and net short bonds. Their position originates from their liabilities which are, to a first order, bond-like (although of course they also depend on inflation and mortality rates). The empirical evidence suggests that during financial crises the correlation between stock returns and bond yields increases dramatically, an effect known as 'flight-to-safety,' where investors sell stocks to buy treasuries (e.g. Fleming and

Remolona 1999; Gulko 2002; Connolly et al. 2005). This results in the liabilities of pension funds rising in value (due to an increase in discount rates) by more than the asset side, depending on the equity/bond mix, thus generating a significant asset-liability mismatch. The correlation between bond and equity markets is likely to again become very important in the future, as bond yields are at historical lows and bond prices appear to be in bubble territory. Going forward, the risk is that short-term interest rates will eventually rise, leading to a significant sell-off in long-term bonds, as last happened in 1994. If central banks raise rates in an environment of improved economic growth and rising stock prices, the correlation between bond yields and stock returns can again suddenly increase.

To illustrate how a pension fund might benefit from a position in a payer stock-bond correlation swap, consider the following stylized example. Liabilities are proxied by 20-year duration bonds, whereas assets are invested in a 60/40 split across stocks and ten-year duration bonds. The split is consistent with the findings of Rauh (2009) and the duration mismatch with J.P. Morgan (2011). For a fully funded plan, we apply a shock of 10 percent to the stock price and the yield curve, which for simplicity is assumed to be flat. Figure 2.3 reports the percentage decrease in the funding ratio resulting from the individual shocks and a joint shock to stocks and bonds. The impact of the interest-rate shock is higher than for stocks due to (a) the mismatch between the asset and liability stock/bond split, and (b) the duration mismatch. The effects are greatly amplified by a simultaneous shock, which can be regarded as a proxy for high stock-bond correlation.

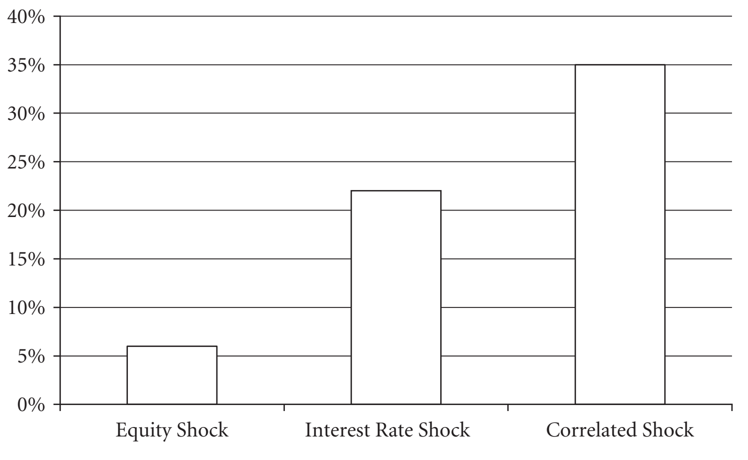

Figure 2.3. Funding ratio at risk from adverse shocks to assets and liabilities.

Note: The figure reports the percentage decrease in the funding ratio from the initial level of 100 percent (i.e. $A = L$), as a result of the 10 percent adverse shock to the stock price level and the (flat) yield curve separately, as well as jointly (correlated shock bar in the plot).

Source: Biffis et al. (2012*b*).

If the correlation between stocks and bonds were completely predictable, a pension fund manager with an ALM mandate would be able to adjust his portfolio today to take account of changes in correlation tomorrow. Although some studies find common factors that display some predictability of the second moments of stocks and bonds (e.g. Viceira 2012), the predictability of correlation is far from perfect out-of-sample. Hence, correlation swaps offer an effective way to hedge against unexpected changes in correlation. Figure 2.4 shows the price (in correlation points) of an OTC swap contract written on the correlation between changes in S&P 500 returns and in the ten-year constant maturity swap (CMS) rate. The swap rate at the end of April 2011 for the swap expiring in April 2012 (2013, 2014, 2015, 2016) was 25 percent (31 percent, 32 percent, 34 percent, 35 percent). An investor could have thus entered a payer correlation swap allowing him to enter a long position in the realized correlation at the price of a fixed correlation level equal to 32 percent over two years.

By taking a position in this product, the pension fund is exposed to the net payments from the instrument at each payment date, as well as to changes in the market's expectation of future stock-bond correlation via the marking-to-market/model procedure. Both the cashflow and mark-to-market channel can provide

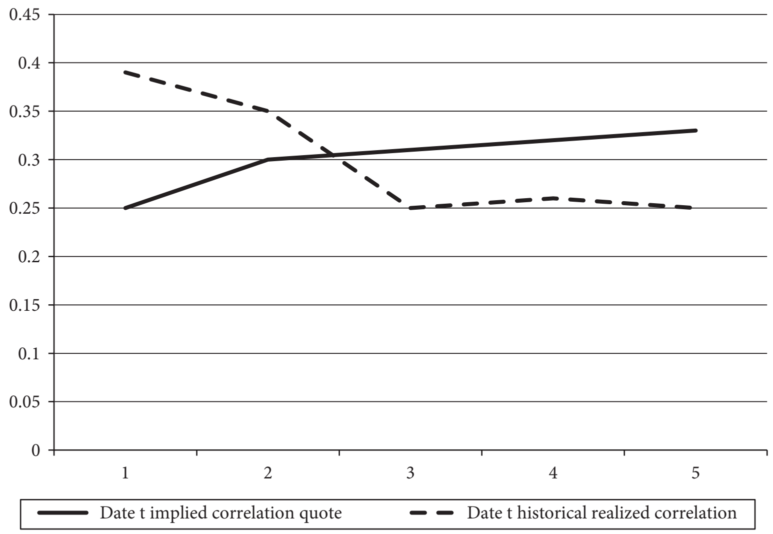

Figure 2.4. Correlation swap rates for different maturities as of April 8, 2011.

Notes: We plot the historical realized correlation (over one to five years to date) for comparison, demonstrating how the swap rate embeds a positive premium for short maturities and a negative premium for longer maturities. Gauging the correlation swap premium heavily depends on the methodology used to estimate the realized correlation.

Source: Biffis et al. (2012*b*); the investment bank which provided these quotes wishes to remain anonymous.

significant benefits *ex post* (in case of market distress) and *ex ante* (for regulatory valuations and stress testing exercises). These benefits typically come at a lower price than for standard tail-risk hedging strategies relying on put options or VIX derivatives. The reason is that the hybrid product provides insurance on a joint event (low stock prices and low yields) that may not occur in a downturn affecting both asset classes simultaneously, or in a stagflation environment characterized by rising yields and falling markets. The product can be priced even more cheaply as a result of the inventories and rebalancing needs of structuring desks operating across the LDI and other spaces.

To provide an example of how a pension fund might go about choosing the allocation to a correlation swap, Biffis et al. (2012*b*) first compute the implied volatilities of stocks and bonds.[7] Using the model-free methodology of Britten-Jones and Neuberger (2000), they back out the one-year implied volatility from options on the S&P 500 index and on ten-year Treasury bonds, and find evidence of time-varying linkages between the implied volatilities of stock and bond options which are not spanned by the available securities (see Biffis et al. 2012*b*). The presence of unspanned correlation risk means that one cannot rely on replication arguments to price the correlation swap. The authors therefore take a stance on preferences and use a utility indifference argument. Specifically, they consider a representative DB pension plan manager with mean-variance preferences on surplus returns; they then determine the correlation swap rate as the fixed leg that zeros the price of the swap at inception and makes the pension fund indifferent between entering the position or not. The dynamics of stock prices and bond yields are modeled (under the realistic measure) with a Wishart process allowing for stochastic volatilities and correlation (see Fonseca et al. 2007, for example).

Calibration of the model to historical data gives model-implied quotes falling within the range of quotes obtained from market participants such as those provided in Figure 2.4. The results on the optimal allocation to the correlation swap are presented in Table 2.3. Biffis et al. (2012*b*) define the surplus as above, where we recall that k captures the importance of the plan's liabilities, the limiting case $k = 0$ representing the asset-only case. From Table 2.3 we see that the optimal allocation to bonds increases as the liabilities become more important (higher k). The optimal allocation to the correlation swap is financed by reducing the position in both equities and bonds, and is decreasing in k. The intuition is that mean-variance optimization increases the allocation to bonds as the importance of the liabilities increases (because bonds have a risk profile closer to that of the liabilities), thus reducing the exposure to stock-bond correlation risk. The higher the pension plan's aversion to the volatility of the surplus, the stronger the effect.

Collateralization of Hedging Instruments

The global financial crisis has highlighted the importance of bilateral counterparty risk and collateralization for over-the-counter instruments, spurring a number of responses from market participants and regulators (e.g. ISDA 2009, 2010*a*).

Table 2.3 Portfolio weights for a pension plan with mean-variance preferences over surplus returns

	$\gamma = 5$			$\gamma = 30$		
k	0	0.5	1	0	0.5	1
Panel A. Without stock-bond correlation swap						
Stocks	0.415	0.371	0.336	0.415	0.262	0.190
Bonds	0.585	0.629	0.664	0.585	0.738	0.810
Panel B. With stock-bond correlation swap						
Stocks	0.401	0.360	0.327	0.401	0.256	0.187
Bonds	0.568	0.612	0.647	0.568	0.723	0.796
Correlation swap	0.031	0.028	0.026	0.031	0.021	0.017

Notes: This table reports the asset portfolio weights for differing values of k, the importance of liabilities, and γ, the risk aversion of the pension plan. Panel A reports the weights for when investable assets include only stocks and bonds. Panel B reports the weights for the case when correlation swaps are available for trade.

Source: Biffis et al. (2012*b*).

Although there is no commonly accepted framework yet for marking to market/model such exotic instruments as longevity swaps, hedgers and hedge suppliers look to other markets to provide a reference model for counterparty risk assessment and mitigation. In interest-rate swap markets, for example, the most common form of credit enhancement is the posting of collateral. According to the International Swap and Derivatives Association (ISDA), almost every swap at major financial institutions is 'bilaterally' collateralized (ISDA 2010*b*), meaning that either party is required to post collateral depending on whether the market value of the swap is positive or negative. Collateralization addresses the concerns aired by pension trustees regarding the safety of hedging instruments, but introduces an additional dimension in the cost/benefit assessment of de-risking solutions. The 'risk premium' embedded in a transaction then reflects not only the compensation for the risk being transferred and the cost of regulatory capital involved in the transaction, but also the expected costs to be incurred from posting collateral during the life of the trade. In an environment where good quality collateral is scarce, counterparty risk mitigation may therefore lead to higher prices and reduce the appeal of OTC instruments commonly used by pension plans in LDI programs.

To give an example, let us consider the case of a longevity swap and first take the perspective of a reinsurer (the hedge supplier) dealing with a pension plan (the hedger). Whenever the swap is sufficiently out-of-the-money to the hedge supplier, the hedge supplier is required to post collateral, which can be used by the hedger to mitigate losses in the event of default. Although interest on collateral is typically rebated, there is both a funding cost and an opportunity cost, as the posting of collateral depletes the resources the hedge supplier can use to meet her capital requirements at aggregate level as well as to write additional business. Conversely, whenever the swap is sufficiently in-the-money to the hedge supplier, the hedge supplier will receive collateral from the counterparty, thus benefiting from capital relief in regulatory valuations and freeing up capital that can be used to sell additional longevity protection. The benefits can be far larger if collateral can be re-hypothecated—that is, if collateral is not segregated and can be re-pledged for other purposes. The same considerations can be made from the viewpoint of the hedger, but the funding needs and opportunity costs of the two parties are unlikely to offset each other exactly. Hence they will ultimately affect the pricing of the hedging instrument. This is particularly relevant for transactions involving parties subject to different regulatory frameworks. In the U.K. and several other countries, for example, pension liabilities are more capital intensive for hedge suppliers, such as insurers, than for pension plans.[8]

Challenges Ahead

Pension plans face a number of challenges threatening the sustainable and orderly provision of retirement income to plan members. Well-known issues affecting the liability side, such as low interest rates and rising life expectancy (e.g. IMF 2012), are exacerbated by dangerous incentives on the asset side ('hunt for yield' in markets distorted by quantitative easing), as well as by a changing regulatory landscape that may force pension plans to recognize funding levels that are much lower than lenient accounting standards might suggest. There is an opportunity for regulation to create the right incentives for sponsors and trustees to consider the value of de-risking strategies, and engage with financial institutions and the insurance community to ensure that the risks of retirement provisions can be shared more widely and more efficiently. We give some examples of current challenges facing the demand and supply of de-risking solutions: collateralization of OTC derivatives; differential regulatory standards in the pension buyout market; and risk-taking incentives in delegated asset management.

A Changing Regulatory Landscape

Both the Dodd–Frank Wall Street Reform and Consumer Protection Act (signed into law by President Barack Obama on July 21, 2010) and the European Market Infrastructure Regulation (EMIR) in Europe are likely to have a major impact on the way financial institutions will manage counterparty risk in the coming years. It is unclear whether centralized clearing will lead to lower utilization of derivative instruments due to scarcity of collateral and funding costs associated with initial margins and possibly variation margins (Singh and Aitken 2009; Heller and Vause 2012; Sidanius and Zikes 2012; Bauer et al. 2013). What seems likely is that, for derivatives exempted from centralized clearing (such as inflation and longevity swaps), pension plans will be treated as 'covered entities' by regulators—in other words, in the same way as financial firms and systemically important non-financial firms. EMIR, for example, captures pension funds as financial counterparties, so one might expect pension plans to be considered as covered entities when E.U. regulators finalize the rules. This could possibly result in pension funds being required to exchange variation margins from the beginning of 2015, after which they would be subject to two-way posting of initial margins that will be segregated (see BIS-IOSCO 2013). These requirements will be phased in over 2015–2019 and will mainly affect large plans. For example, only covered entities with more than a notional €3 trillion of non-cleared swaps will be subject to these initial margin requirements, whereas entities with less than €8 billion of non-cleared swaps will be required to meet the requirements from 2019 onwards. The proposals currently being discussed suggest that initial margins will rely on standard risk measures (value-at-risk at 99 percent confidence interval over a 10-day horizon) computed with a model or standard tables. Eligible collateral will range from cash and bonds to corporate bonds and major equity indices (with haircuts).

The costs associated with these regulatory changes could be significant. For smaller and larger plans, in particular, the collateral management process will have to become an integral part of ALM and LDI. This could make pension buyouts and buy-ins more appealing because of their 'hedge and forget' nature, although the regulatory changes described above will also affect the LDI programs of buyout firms, making buyouts more expensive.

At the same time, recent innovation in the European marketplace is making it easier for smaller plans to cope with counterparty risk mitigation protocols. For example, the Credit Support Annex (CSA—the legal document that supports the collateral of derivatives transactions; see ISDA 1996) may now take the form of an umbrella CSA covering a consortium of pension plans engaging in LDI with a common asset manager. It is also increasingly common to see multi-currency cash/bond CSAs, as well as investment-grade credit CSAs, offering pension plans the option to deliver collateral in different forms and currency. Similarly, there are instruments being designed around the collateral management process, such as margin lending facilities and collateral swaps.[9] This suggests that the tools to respond to regulatory changes are already available and are being currently tested in the LDI programs of several pension plans.

Pension Buyouts and Regulation

Biffis and Blake (2013) explain the mechanics of pension buyouts by looking at the role of informational asymmetries and differences in regulatory standards between hedgers and hedge suppliers. They show that the adverse selection problem faced by unsophisticated pension plans (a seller's curse) transferring their liabilities to more informed insurers subject to stricter regulatory rules can have an adverse impact on prices, and has prevented a number of pension plans from accessing the buyout market. This suggests that greater transparency on the liability side could provide a more level playing field for pension plans and buyout firms. On the other hand, naive information disclosure may exacerbate the adverse selection problem by making informed buyers even more informed.

There is an opportunity here for regulators to align the broad actuarial assumptions used in DB pension accounting with a more realistic assessment of market risk and longevity risk, while leaving the choice of detailed information disclosure to pension funds and their advisors. This could favor the aggregation of liabilities and bulk buyouts (as a tool to reduce the information advantage of buyout firms), while narrowing the gap between buy-side and sell-side valuations due to differences in regulatory environments. Transparency can further have a beneficial effect in the secondary market for pension liabilities (e.g. the market for insurance-linked securities), as it mitigates the adverse selection problem faced by investors acquiring longevity-linked securities issued by buyout firms. Here, specialized insurers can use their information advantage to suitably pool longevity exposures and issue securities minimizing the impact of information asymmetries (e.g. Biffis and Blake 2010*a*). Regulators can therefore play an important role, for example by requiring rating agencies to use sufficiently granular data to assess the risk profile of securitized products, or by providing incentives to disclose and use detailed information from the very same internal models used to demonstrate the capital resilience of buyout firms in the primary market.

Risk-taking Incentives in Delegated Asset Management

Anchoring asset management to long-term liabilities via surplus-based performance measures leads to complex risk-taking and risk mitigation incentives. The value of assets and liabilities depends on regulation and accounting rules. On the asset side, financial instruments may be valued by using average historical yields to smooth out fluctuations in prices, or using historical cost rather than market value (e.g. under the accounting standard IAS 39, historical cost can be used for instruments classified as held-to-maturity as opposed to available for trading). On the liability side, accounting rules often rely on simplified and unrealistic assumptions that result in a distorted representation of the risk profile of pension liabilities (e.g. the use of outdated mortality tables in discounting future liabilities). The recent push toward market-consistent valuation methods (e.g. IAS 19, IAS 39, and IFRS4) has mitigated the distortions induced by accounting measures, at the price of introducing substantial short-term volatility in funding ratios and liability portfolios and giving rise to considerable modeling uncertainty when non-tradable risks (such as longevity risk) are considered (e.g. Biffis et al. 2010). The first effect is due to the use of market-implied information that may diverge from long-term fundamental values; the second is due to model risk (a reference model is used to compute market-consistent values) and parameter risk (mark-to-model exercises are affected by uncertainty in parameter estimates). On the one hand, discounting by current yields guarantees an accurate description of the fund's financial situation. On the other, using a constant yield smooths out temporary fluctuations in the present value of the liabilities and gives a longer-term description of a fund's financial condition.

Risk-taking incentives can be classified as arising in the presence of *ex ante* prevention measures (e.g. short-sale and other constraints in asset allocation, Value-at-Risk constraints) and *ex post* punishment (such as curb in compensation, reputational losses, or the costs associated with additional funding from the sponsors). Despite their relevance, these issues are still largely unexplored. We now review some recent contributions offering some interesting insights on the trade-offs at play in this space.

Van Binsbergen and Brandt (2009) study the impact of regulations on the investment decisions of a DB pension plan. In their model, the optimal asset allocation decisions of the investment manager are a function of the plan's funding ratio (defined as the ratio of its assets to liabilities), interest rates, and the equity risk premium. They compare the optimal investment decisions under several policy alternatives to understand better the real effects of financial reporting and risk management rules. They evaluate the influence of *ex ante* (preventive) and *ex post* (punitive) risk constraints on the gains to dynamic, as opposed to myopic, decision-making. They show that, in their model, preventive measures, such as Value-at-Risk constraints, tend to decrease the gains to dynamic investment. In contrast, punitive constraints, such as mandatory additional contributions from the sponsor when the plan becomes underfunded, lead to very large utility gains. They also show that financial reporting rules have real effects on investment behavior. For example, they argue that the current U.S. requirement to discount liabilities at a rolling average of yields, as opposed to at current yields, induces grossly suboptimal investment decisions. The way liabilities are computed can drive an important wedge between the fund manager's long-term objective of maximizing the funding ratio and his short-term objective (and/or requirement) of satisfying risk constraints and avoiding additional financial contributions from the plan sponsor.

Buraschi et al. (2012) study the implications of non-linear managerial incentives and funding contracts for risk-taking and traditional reduced-form tests of performance attribution for hedge funds. The authors solve the structural optimal portfolio choice problem of a hedge fund investor who is subject to (a) performance fee-based incentives, (b) funding options by the prime broker, and (c) equity investors' redemption options, which together create a non-linear payoff structure that affects endogenous hedge funds' risk-taking. The resulting optimal portfolio choice is state-dependent due to the time-varying endogenous incentives perceived by the manager, depending on the distance of the assets under management from the high-water mark. This implies that optimal leverage and reduced-form alphas fluctuate over time. This is important since it implies that traditional performance regressions with constant coefficients are potentially mis-specified. The call option-like performance fee incentive motivates the manager to use more leverage, while put option-like features (together with the concern about the future value of the incentive options) induce the manager to reduce leverage when his fund underperforms below a given threshold. Although this study uses hedge funds in the empirical application, its results have a much broader economic motivation. Separating the effect of risk-taking and skill, based on observed investment performance, is a fundamental problem that affects not only investors in alternative investment funds, but also investors in (and regulators of) levered financial institutions such as investment banks or pension funds which employ incentive contracts.

Ang et al. (2012) note there are significant penalties associated with the failure to meet liabilities which are not captured by the variance of the surplus return in the static surplus return maximization. They also point out that the 2006 Pension Protection Act (PPA) in the U.S. required that plan funding equal 100 percent of the plan's liabilities, so underfunded plans were required to fund their plans according to rules that result in higher employer contributions.[10] The authors list additional downside risks associated with underfunding such as higher insurance premia, holding higher reserves, and the opportunity costs associated with transferring money to the pension plan, as well as the cost to beneficiaries who face higher default risk of their plan. To incorporate these real-world effects into their model, the authors propose a new model that incorporates downside risk penalties for not meeting liabilities. In their model, the shortfall between the asset and liabilities can be valued as an option which swaps the value of the endogenously determined optimal portfolio for the value of the liabilities. The optimal portfolio selection exhibits endogenous risk aversion and as the funding ratio deviates from the fully funded case in the direction of underfunding or overfunding, effective risk aversion decreases. When funding is low, it is optimal for the manager in the model to take on risk, betting on the chance that liabilities can be covered. When the plan is overfunded the manager also takes on more risk, as liabilities are already well matched, and so the manager decides to invest aggressively in risky securities. In contrast to Detemple and Rindisbacher (2008), where shortfall costs have a utility cost for a risk-averse fund sponsor, the shortfall cost is reflected in an actual real-world value through an option calculation in Ang et al. (2012).[11] Amenc et al. (2010) also present an LDI model that incorporates an option, but it is exogenous rather than endogenous in their framework.

Conclusion

This chapter reviewed the key drivers behind the emergence of LDI, illustrating the main principles behind this variant of ALM, as well as some of the most commonly used hedging tools. We also described several emerging de-risking tools such as pension buyouts/ins, longevity swaps, and tail-risk hedges that have gained popularity in light of the rise in cross-asset correlation associated with quantitative easing. Some of the main challenges ahead include changes in pension regulation, centralized clearing of OTC derivatives, and risk-taking incentives in delegated asset management for pension ALM.

Notes

1. Other examples include Boulier et al. (1995), Sundaresan and Zapatero (1997), Cairns (2000), and Van Binsbergen and Brandt (2009).
2. The authors examine a dynamic asset allocation problem of a fund manager with von Neumann–Morgenstern preferences with (a) terminal utility function defined over the excess of liquid wealth over minimum liability coverage tolerated, and (b) intermediate utility function defined over dividends.
3. See, for example, Biffis and Blake (2010*b*, 2013).
4. A quanto option is a cash-settled option whose payoff is converted into a third currency at maturity at a pre-specied rate, called the quanto factor. In our case, the pension payments toward a homogenous cohort of pensioners are obtained by multiplying the payments due to a representative pensioner by the number of survivors in that cohort. A similar feature exacerbated the problems faced by Equitable Life when dealing with guaranteed annuity options (see Biffis and Millossovich 2006).
5. For details on the collateralization of these instruments and its impact on their valuation, see Biffis et al. (2012*a*).
6. This section draws on Biffis et al. (2012*b*).
7. Such an approach is justified by the work of Fleming et al. (1999), Chordia et al. (2005), and Connolly et al. (2005), who find evidence of volatility linkages between stock and bond markets which also drive the correlation between these markets.
8. See Biffis et al. (2012*a*), and Biffis and Blake (2013), Davis (2014), and Lundbergh et al. (2014) for additional discussion.
9. 'In these arrangements a [pension plan] lends a bank liquid securities such as government bonds—for which the bank pays a small fee—and in return the bank pledges highly rated but less liquid collateral such as mortgage-backed securities—bonds backed by pools of loans—where the markets are still tainted by the "toxic" tag from the financial crisis' (Hughes 2011).
10. Ang et al. (2012) illustrate the penalties associated with underfunding by pointing to the case of AT&T, whose funding status changed from $17 billion surplus in 2007 to a nearly $4 billion deficit in 2008, contributing to the decline of AT&T's stock from 2007 to 2008.
11. They specify the objective function of the fund as mean-variance over the asset returns plus a downside risk penalty on the liability shortfall:

$$\max_W E(r_A) - \frac{\gamma}{2}\text{var}(r_A) - \frac{c}{A_0} P(W, L_0, A_0)$$

where *c* is a penalty cost associated with the downside and $P(w, L_0, A_0)$ is the endogenous value of the option as the fund manager can reduce the value of this option by increasing the correlation of the optimal portfolio with the pension liabilities.

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