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Solvency Tests for Dutch Pension Plans

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Introduction

One of the important tasks of the Chief Financial Officer of a pension plan is to assure long-term solvency of the fund. Participation in pension plans is obligatory for almost all employees in the Netherlands. The identity of the employer dictates the pension plan in which one has to participate. Pension plans hold a premium option, since they can increase future pension premiums to solve solvency problems. However, there are limits to the use of the premium instrument. Because participants can avoid premium increases by switching jobs and because plan sponsors can go bankrupt, strict solvency rules are deemed essential by the legislator.
The key parameter in solvency supervision is the funding ratio, which is defined as the ratio of the market value of the assets over the market value of the liabilities. Dutch pension plans are at all times required to have a funding ratio of at least 105%. Moreover, a solvency test imposes that the probability of the funding ratio dropping below 100% within one year from now should at all times be less than 2.5%. If this solvency test is violated, a recovery plan[1]] is to be submitted that assures that adequate solvency buffers will be rebuilt within the following 15 years. Long-term solvency is evidently an important objective for every pension plan. Moreover, violations of the regulatory rules can lead to undesirable fluctuations in pension premiums or sponsor contributions and to a reduction of the rights of the participants. Not surprisingly, measurement and management of the solvency risk is of vital importance for Dutch pension funds.
The Dutch prudential supervisor, De Nederlandsche Bank (DNB), has recently proposed a new regulatory framework. The required solvency of a pension plan can be determined using a standardized approach (SA) that is easy to implement for many funds. This in itself is a very significant step forward compared to the ad-hoc rules that have been used before. The availability of such a SA will encourage model-based risk management and will serve as a benchmark for alternative models. The supervisor encourages the use of internal risk management models (IMs) rather than the SA. In this paper, we outline the implicit model underlying the standardized approach and relate it to a simple internal model.

The scenario generator for the standardized approach and a stylized internal model

The market value of assets and liabilities of a pension fund depends on a number of underlying factors. Modelling requires a reduction of the total number of risk factors to a limited set. A simple internal model could, for example, be based on the assumption that all market risks can be captured by exposures to the nominal interest rate with one year to maturity, the inflation rate and returns on a number of stock, currency, real estate and commodity indices. More specifically let $y_t' = (R_t^{(1)}, \pi_t, x_t')$ be the state vector for the model, where $R_t^{(1)}$ is the annual nominal rate, π_t is the current inflation rate and xt is a vector of returns on the indices referred to. We are focusing specifically on the model where

$$R_{t+1}^{(1)} = {}_R + \gamma_{11} (R_t^{(1)} - {}_R) + \gamma_{12} (\pi_t - {}_\pi) + \varepsilon_{R,t+1} \quad (1)$$

$$\pi_{t+1} = {}_\pi + \gamma_{21} (R_t^{(1)} - {}_R) + \gamma_{22} (\pi_t - {}_\pi) + \varepsilon_{\pi,t+1} \quad (2)$$

$$x_{t+1} = {}_x + \varepsilon_{x,t+1} \quad (3)$$

$$\varepsilon_{t+1} \sim \text{i.i.d. } N(0, \text{Diag}\{\Sigma_{R\pi}, \Sigma_x\}) \quad (4)$$

with $\varepsilon_{t+1}' = (\varepsilon_{R,t+1}, \varepsilon_{\pi,t+1}, \varepsilon_{x,t+1}')$. This model in (1)-(4) generates nominal interest rates with n periods to maturity, $R_t^{(n)}$, as well as the corresponding real rates $R_t^{R(n)}$, if we complement it with simple affine term structure models:

$$R_t^{(n)} = a_n + b_n R_t^{(1)} + c_n \pi_t \quad (5)$$

$$R_t^{R(n)} = a_n^R + b_n^R R_t^{(1)} + c_n^R \pi_t \quad (6)$$

The model in (1)-(6) is a good workhorse model to address the model underlying the SA. Of course (1)-(6) could be refined in many directions. For example, the model assumes that the term structures can be generated by only two factors, that all innovations are homoscedastic and ignores predictability of stock returns, for example on the basis of dividend yields or past returns. It is assumed in the sequel that such refinements are not too relevant for managing solvency risk at an annual horizon, although they might be quite important for addressing the long-term perspective of the fund using ALM models.

The measurement of nominal interest risk in the SA is based on a table with maturity-dependent shock factors fn that is to be applied to generate scenarios for the term structure one year from now: $R_{t+1}^{(n)} = f_n R_t^{(n)}$. Some characteristic values for f_n are $f_1 = 0.65$, $f_{10} = 0.78$ and $f_n = 0.81$ ($n > 25$). The implicit term structure model can be approximated by the model in (1)-(6) if $\gamma_{11} \sim 1$; $\gamma_{12} = 0$ and $c_n = 0$. The link between the shock factors and the coefficients in (1)-(6) is given by $(1 - f_1)/(1 - f_n) \sim b_1 / b_n$ since both ratios specify the relative shock size for short relative to longer rates, assuming that the initial term structure is flat.

A large empirical literature addresses the validity of the assumptions imposed by the SA on (1)-(6). While the SA, unlike the textbook use of duration analysis, has the property that long interest rates are assumed to be less volatile than short rates if the initial term structure is approximately flat, most affine term structure models that have been estimated in the literature assume that the long rate is constant, i.e. bn = cn = 0 for large n. The assumption $f_n < 1$ for large n which underlies the SA might therefore lead to larger solvency buffers than those generated by IMs.

The SA assumes that the inflation affects the value of assets and liabilities through changes in the long-term expected inflation only. Moreover, it is assumed that changes in the long-term expected inflation are fully correlated with nominal interest rate changes so that real rates are approximately constant. In (1) – (6) this implies $\gamma_{22} = 1$, $\gamma_{21} = 0$ and $b_n^R = c_n^R = 0$. IMs will typically assume that inflation is mean reϖεrting, which reduces the required buffers, and that short-term fluctuations in inflation do have an impact on the real term structure. The latter increases the required solvency margin.

Worst case scenario selection for the standardized approach and a stylized internal model

The solvency test that is imposed by Dutch legislation focuses entirely on the 2.5% quantile of the distribution of the funding ratio. A drawback of this rule is that the amount of underfunding if the threshold is violated does not play any role in the determination of solvency buffers. The test that is imposed is equivalent to specification of a maximum Value at Risk as a percentage of wealth in banking supervision. It is well known that coherent risk measures that do take additional downside risk into account, such as expected shortfall, are to be preferred from a theoretical perspective. An IM can, of course, easily be simulated in order to compute the standard solvency tests as well as coherent downside risk measures.

The solvency test in the SA can easily be interpreted as being based on the assumption that returns on assets and liabilities are normally distributed[2] with mean zero[3] and known variances. The buffer S1 that is required for interest and inflation risk is determined by considering the price impact of the fluctuations in the term structures outlined before. In the SA the volatility of the innovations in interest rates that is assumed depends on the interest rate level, which we excluded in the stylized internal model (1)-(6). If the initial curve is well approximated by a flat rate at 5%, the SA is approximately equivalent to an annual volatility of 0.5% in the IM.

The risk factors that are considered in this section on top of interest and inflation risk are stock market risks, currency risk, commodity risk and real estate risk. Stock market risk is further decomposed into the subcategories of risk in mature markets, and emerging market and private equity risk, which are assigned volatilities of 12.5% and 15.0% respectively. Compared to estimates that are commonly used in internal models these seem to be rather low[4]. The risks of all categories are assumed to be perfectly correlated within categories and uncorrelated across categories. Interest rate risk and stock market risk are assumed to have a correlation of 0.65 in the SA. Interest rate risk is assumed to be independent of exchange rates, commodity and real estate prices. Straightforward algebra shows that under these assumptions the total required buffer can be computed as

$$S = \sqrt{[S_1^2 + S_2^2 + 2 * 0{,}65 * S_1 * S_2 + S_3^2 + S_4^2 + S_5^2]}, \qquad (7)$$

where S_1 is the required buffer for interest and inflation exposure and S_i for $i > 1$ refers to stock market, currency, commodity and real-estate exposure respectively.

The correlation that is assumed in (7) between the price effects of interest rate changes and stock returns, roughly corresponds to a correlation between changes in annual interest rates and stock returns. The value of 0.65 seems far off from estimates that have been reported in the literature. Campbell et. al (2003)[5], for example, report a correlation of –0.135 for annual US data over the sample period 1890-1998. Direct estimates of the correlation between annual returns on Dutch stocks and Dutch bonds with maturities of 5-10 years over the period 1985-2005 give estimates in the order of magnitude of 0.05 to 0.10. Internal models that assume smaller or negative correlations than is the case in the SA will generate smaller buffer requirements.

Both the SA and the IM will have to rely on asset-pricing models that transform fluctuations in underlying fundamentals to changes in the market value of assets and liabilities. For now, the SA allows approximation of the portfolio of liabilities by a single obligation with the same market value and duration and subsequently determines the value effect of fluctuations in the interest rates with maturity equal to that specific duration. While this is the adequate calculation within the full framework of duration analysis, the assumption that long rates fluctuate less than short rates implies that the duration of the liabilities is no longer an adequate summary statistic for the interest exposure of the liabilities.

A more consistent framework would be to discount all future expected cash flows against the term structure in the scenarios of decreasing or increasing interest rate risks.

Explicit or implicit pricing models are also required to translate value fluctuations in stock return and currency indices into value fluctuations of stock and currency portfolios. The SA assumes that all stocks have unit exposure to a single stock-market index and that assets are either not or not fully correlated with a single currency index. Last but not least, asset pricing models are vitally important if pension funds are invested in hedge funds or non-linear derivatives, for example. The SA assumes that these exposures can be translated into a delta-equivalent direct stock-market exposure.[6] Computation of this delta-equivalent will usually be far from trivial and of a complexity that does not fit the use of the SA.
Note that up to this point we have assumed monotonicity of the mapping from fundamentals to values so that the most extreme scenarios in the underlying fundamentals correspond to the most extreme effects for the funding ratio. Monotonicity is vital for the straightforward use of the standardized approach. Simulation-based internal models do not require the monotonicity assumption and will automatically detect the worst case scenarios.

Miscellaneous risk factors

In addition to the risk factors discussed so far, the SA explicitly refers to longevity risk, volatility risk, concentration risk and operational risks. In this Section we will briefly address these risk factors.

The SA assumes that longevity risk is idiosyncratic at an annual horizon. Macro-longevity risk, like an unexpected overall increase in the quality of health care, is not idiosyncratic. The assumption that this risk is small relative to market risks at an annual horizon seems natural, although macro longevity risk is potentially important at longer horizons.
Volatility risk is treated in the SA as changes in a single volatility factor irrespective of the maturity of the exposure. IMs can distinguish between a number of equity markets and currencies and can reflect a term structure of volatilities. The SA does not seem very appropriate for pension plans with significant volatility risk.
If stock or bond portfolios are not sufficiently diversified or significant counter-party risk is present, the SA prescribes that buffers are held to cover the concentration risk. Little guidance is given on how to determine an adequate size for these buffers. Finally, operational risk is announced as an important risk factor that is to be taken into account as soon as adequate modelling approaches are available. As in the case of derivative positions or hedge funds, the use of an IM seems much more adequate than the use of a SA if concentration and/or operational risks are present.

Conclusions

For many years, Jean Frijns has emphasized the use of adequate modelling tools as an important input for the investment process of a pension fund. He has therefore strongly encouraged interaction between academia and the asset-management and pensions industries. His efforts to stimulate initiatives with this aim (including Inquire Europe, the Tilburg Center of Finance, Netspar[7]) as well as his personal encouragement of many academics to discuss real-life issues, have substantially reduced the gap between academia and practitioners.
The new solvency tests give an impulse to the use of modelling tools in the financial industry. In this note, we compared the use of the SA (sufficient for the supervisor) and IMs (encouraged by the supervisor) in implementing solvency tests for Dutch pension plans. The availability of a SA is of significant importance in encouraging model-based risk management in the sector and sets a benchmark. IMs can be tailor-made to the specific characteristics of the fund. IMs also have a potentially very important drawback relative to standardized models. If the IMs are insufficiently understood and evaluated by independent experts, they can easily carry a lot of model risk in that misspecification if the model strongly affects buffer requirements. Explicit comparison of all results generated by an IM with a well understood standard model like the SA is a tool for mitigating model risks.

Notes

1] Note that the recovery plan can be deterministic. A projected extreme equity exposure is therefore encouraged as one ingredient of satisfying the requirements for the recovery plan.

2] Normality is not assumed explicitly in the SA. If asset returns would be assumed to be fat tailed, smaller volatilities are needed to have the buffer requirements consistent with a 2.5% probability of underfunding.

3] This is suggested by the fact that the shock intervals are symmetric, i.e. expected returns are ignored. Note that the expected returns can have a sizable impact on the buffer if an internal model is used. If pension funds are assumed to have long exposure to equities, only the lower bound of the shock interval (-25%) affects the buffer. The SA can therefore also be reinterpreted as assuming say an expected equity return of 8% and a volatility of 16.5%.

[4] See also footnote 4. Even a value of 16.5% seems to be on the low side, compare for example e.g. Dimson, Marsh and Staunton (2001).

[5] Campbell J.Y., Y.L Chan and L.M. Viceira (2003), *A multivariate model of strategic asset allocation, Journal of Financial Economics,* 67, 41-80.

[6] Alternatively, hedge funds can be treated like private equity in the SA. This seems a very crude way to treat hedge fund exposure.

[7] The author is academic coordinator of Inquire Europe as well as Scientific Director of the Tilburg Center of Finance and Netspar.