Netspar Network for Studies on Pensions, Aging and Retirement

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Strengths and Weaknesses of the Dutch Standardized Approach to Measure Solvency Risk for Pension Plans

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1. Introduction

Measurement and management of the solvency of the pension plan is one of the key responsibilities of the trustees of a plan. If the sponsor does not underwrite the liabilities of the fund (as is the case in the Netherlands), solvency of the fund itself will also be a major concern for the regulator as well as for the participants in the plan, unless continuity of the fund is assured and all risks can be shifted to future generations. If the sponsor is liable for deficits in the pension fund, as is usually the case in the US and the UK, the strength of the sponsor is relevant as well to judge whether the pension obligations can be met[2]. The solvency of the fund itself is in these cases nevertheless also of prime importance because it can be an important determinant of the solvency of the sponsor and because fluctuations in the solvency of the fund are to be reported in the financial statements of the sponsor under the new International Financial Reporting Standards.

The Dutch prudential supervisor, De Nederlandsche Bank (DNB), has recently proposed a new regulatory framework (nFTK). The required solvency of a pension plan can be determined using a standardized approach (SA) that is very easy to implement. The standardized approach distinguishes six risk categories: stock market risk, currency risk, interest rate risk, commodity risk, credit risk and actuarial risk. Required risk buffers S_i (i=1,..,6) are determined for each risk category, assuming that all risks within the category are perfectly correlated. Subsequently the overall risk buffer S is determined using a square root formula:

$$S = \sqrt{(S_1^2 + S_2^2 + \ldots + S_6^2 + 0.65 * S_1 * S_3)} \qquad (1)$$

As the formula indicates, risks between the categories are assumed to be uncorrelated, apart from stock market and interest rate risks which are assumed to be strongly correlated.

A slightly extended version of this SA approach can be used to compute the probability distribution of the future funding ratio under market valuation. The availability of such an accessible method to understand solvency risk is a very

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[2] McCarthy and Neuberger (2005) indicate e.g. how the solvency of the sponsor affects fair premiums to a pension guarantee fund.

significant step forward, and the method will no doubt serve as a benchmark for more elaborate models. This paper will first of all sketch the SA, indicate how it will be used in the Dutch regulatory framework and how it can be extended to be useful for solvency management in general. The core of the paper is devoted to an analysis of the assumptions made in the SA, how they can affect the risk estimates and how these assumptions can be avoided.

2. **Solvency requirements for Dutch pension plans**

Most Dutch pension deals have a nominal DB component in that fixed nominal rights are offered, irrespective of the investment returns. Indexation with price or wage inflation is usually offered conditionally on an adequate funding status of the fund. The solvency requirements focus on the risk that the plan would not be able to meet the nominal obligations.

The key parameter in solvency supervision in the nFTK is the funding ratio, which is defined as the ratio of the market value of the assets over the market value of the liabilities. In the computation of the market value of the liabilities only legally binding obligations are taken into account and in particular the aim to provide inflation indexation is typically not incorporated. Dutch pension plans are at all times required to have a funding ratio of at least 105%. If the funding ratio would drop below 105% a recovery plan is to be submitted which stipulates how the problem will be solved within one year, e.g. through additional contributions of the sponsor or premium increases. A solvency test moreover imposes that the probability that the funding ratio drops below 100% in one year from now should at all times be less than 2.5%. If this solvency test is violated a recovery plan is to be submitted that assures that adequate solvency buffers will be rebuilt within the next 15 years.

3. The (extended) standardized approach to stock market risk

The Dutch supervisor, DNB, has provided a standardized approach to determine whether or not a fund satisfies the solvency test. In this section we will outline the approach assuming that a fund faces stock market risk only and indicate how an extension of the approach can be used to determine the probability that the funding ratio will drop below the 100% or 105% level. All other risk factors to be considered in the sequel are for now assumed to be either negligibly small, reinsured or hedged.

The SA prescribes a buffer of 25% for stock market risk in developed markets. The SA does not make distributional assumptions on the asset returns, but the approach is more straightforward to interpret if a multivariate normality assumption is imposed[3]. This is what we will refer to as the extended standardized approach (ESA). The expected return on risk category i will be denoted by μ_i with corresponding standard deviation σ_i. The buffer of 25% for (not necessarily diversified) developed equity markets risk to reduce the probability of underfunding to 2.5% implies $\mu_i - 2\sigma_i = -25\%$. This is consistent e.g. with an expected return of 8% and a volatility of 16.5% which seems rather low[4]. Note the required buffer of 25% for a developed equity

[3] The square root formula is consistent with other elliptical distributions as well.
[4] If a fat tailed distribution would have been assumed the implied volatility would be even lower.

market portfolio without currency risk implies that the required current funding ratio would be 1/(1-0.25) = 133%.

The strength and weakness of this first component of the SA is that all risks are fully pooled and that many ways in which the risk estimate could be fine-tuned are ignored. The assumption that all risks are fully correlated ignores diversification benefits. The rather low implicit volatility parameters in fact assume that only diversified portfolios are considered. It is straightforward to extend the method to incorporate such diversification benefits along the lines of (1). Predictability and conditional heteroskedasticity of stock returns, time varying correlations and non-linear dependencies could all be incorporated but would require substantially more sophisticated modelling and would often have to be based on Monte Carlo simulations.

3. Currency risk

Currency risk is incorporated in the SA as a single risk factor, irrespective of the currency under consideration. This assumes that only balanced currency exposures are to be incorporated in the risk estimate. The imposed buffer for pure currency positions is 20% in the SA which translates into a volatility $\sigma_2 = 10\%$ assuming that the expected currency return is negligible: $\mu_2 = 0$. Stock market risks and currency risks are aggregated assuming that they are uncorrelated. It is straightforward to show that in the extended standardized approach the buffer requirement would be

$$S = -(f_1 \mu_1 + f_2 \mu_2) + 2 \sqrt{(f_1^2 \sigma_1^2 + f_2^2 \sigma_2^2)} \qquad (2)$$

where f_i is the fraction of the value of the liabilities affected by risk factor i. Equation (2) of course implies that S_i, buffer requirement per risk category as a percentage of the value of the liabilities, satisfies $S_i = -f_i \mu_1 + 2 \sqrt{(f_i^2 \sigma_i^2)}$. Equation (2) therefore simplifies to the square root formula

$$S = \sqrt{(S_1^2 + S_2^2)} \qquad (3)$$

used in the SA (see (1)) if the expected returns on both risk categories are set to zero. The SA thus ignores the fact that risk buffers due to high expected returns and high volatilities are to be increased less in case of additional risk exposure than buffers that are due to low expected returns and low volatilities. It is of course straightforward to implement (2) rather than (3) in an Excel spreadsheet that does the relevant calculations. Here as well models that would distinguish between different currencies can be constructed in the same spirit. Models that allow for fat tails or conditional heteroskedasticity will typically require simulation.

A numerical example is useful to illustrate both the buffer requirements, the calculation of probabilities of underfunding (funding ratio below 100%) or of hitting the trigger for a one year recovery plan (funding ratio less than 105). The numerical example will also illustrate the impact of the use of (3) in the SA rather than (2) which is implied by the ESA.

We consider a pension plan that is exposed to developed market equity risk and to currency risk only. Interest rate risk, credit risk, longevity risk etc. are as before assumed to be hedged or reinsured. We consider four different stock portfolios (see Table 1 and 2): fully invested in Euro-denominated equity, fully invested in equities of which one half invested in non-Euro equity, 50% in equities of which one half with currency exposure and 25% of wealth purely in non-Euro equity. Throughout we assume that the expected return on all equities is 8%. Table 1 shows that the size of the buffer that is needed to reduce the probability of underfunding is strongly risk based. For pure Euro equities portfolios the SA requires a buffer of 33% (see above) while for the fourth portfolio the required buffer is 8.7%. The required buffer increases somewhat if non-Euro equities are involved. As indicated in columns five and six, the buffer requirements are reduced somewhat in the ESA where it is acknowledged that the buffers per risk category are small in part due to high expected returns. For the one year horizon considered here this effect is numerically not very important though.

The ESA can also be used directly to compute the probability that next year's funding ratio would be less than 100% or 105% or any arbitrary number. The results in case of pure equity and currency exposure are reported in Table 2. Note that, as argued in the introduction, such probability statements are quite important for pension plans irrespective of any requirements imposed by the regulator. Awareness of such probabilities due to the availability of simple models like the SA can result in a major boost of the quality of risk management of pension plans, not unlike the boost in risk management of banks due to the Value at Risk concept in the early nineties.

Table 1: Funding ratios required by DNB for pure equity and currency exposure according to SA and ESA

Fraction of value of liabilities exposed to		Buffer		Required funding	
Equities	Non-Euro equity	SA	ESA	SA	ESA
100%	0%	25%	25%	133.3%	133.3%
100%	50%	26.9%	26.5%	136.8%	136.0%
50%	25%	13.5%	13.2%	115.6%	115.3%
25%	25%	8.0%	7.6%	108.7%	108.3%

Table 2: Probability of funding ratio below three thresholds for pure equity and currency exposure

Fraction of value of liabilities exposed to		Current funding ratio	Probability of next year's funding ratio below		
Equities	Non-Euro equity		90%	100%	105%
100%	0%	133.3%	0.7%	2.5%	3.8%
50%	25%	133.3%	0,0%	0.0%	0,2%
50%	25%	115.3%	0,1%	2,5%	6,7%
25%	25%	107.5%	0.0%	3.1%	18.5%

4. Interest rate risk

Due to market valuation, interest rate risk has become a major component of the market risk of pension plans. Duration analysis can be used as a tool to estimate the sensitivity of the market value of assets and liabilities to change in the interest rates.

The duration of the liabilities of most Dutch pension funds, D_L, is approximately 15 years. Now assume that with only 2.5% probability the term structure of interest rates would drop by more than 0.8%. The corresponding buffer for interest rate risk according to duration analysis would be 0.8% * (D_L – D_A) where D_A is the duration of the assets.

Duration analysis applies if the term structure can be characterized by a one factor model that allows for parallel shifts only. This model is well known to be misspecified. In the SA, duration analysis has been replaced by a single factor CIR-like specification that takes into account that very long rates are not as volatile as short rates. More details on this procedure and the link to factor models of the term structure are provided in Nijman (2004). The academic literature provides numerous more detailed term structure models that could be used e.g. to allow for possible changes in the steepness and curvature of the term structure. Exposure to such factors can easily be incorporated in the square root formula. The discussion below is not affected by the precise way in which the interest rate buffer S_3 is set.

In the SA, interest rate risk is aggregated with equity and currency risks by assuming a very substantial correlation between interest and equity risk, see (1). This correlation is surprising and seems at odd with empirical observations. Campbell et. al (2003)[5] e.g. 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. Models that assume smaller or negative correlations than is the case in the SA will generate smaller buffer requirements. It is straightforward to check that a fund that invests 50% in equity and 50% in zero coupon bonds with five years to maturity the required funding ratio is 129% if the correlation is taken into account in (1) but only 121% if it is set to zero.

5. Longevity risk

Longevity risk for pension funds or life insurers comes in two very different forms. Even without any change in the quality of the health care system, life style, smoking habits etc. smaller funds face longevity risk because realized survival for their participants can differ from the survival probabilities. This form of longevity risk is known as micro longevity risk and is taken into account in the SA by requiring a buffer (S_6) of 30 basis points[6] over the square root of the number of participants. In the ESA this risk can easily be incorporated by approximating the binomial distribution by a normal one.

Macro longevity risk refers to the impact of changes in the survival probabilities due to improvements in health care, change in e.g. eating and smoking habits, external factors such as wars etc. A variety of models is available nowadays to model survival probabilities and macro longevity risk[7]. These models relate macro longevity risk to a limited number of underlying uncorrelated factors and can thus be relatively easily be

[5] See Campbell et. al (2003).
[6] This applies for couples with partner pensions. For individuals 50 bp. is required.
[7] See e.g. Renshaw and Haberman (2003).

incorporate in the SA or ESA as well[8]. Not surprisingly, it can be shown[9] that macro longevity risk is numerically very important for large funds that hedge their financial risks and less so for smaller funds that take market risk.

6. Inflation risk

One of the main limitations of the SA as discussed so far is that inflation exposure has not been addressed. Inflation exposure of pension plans is an intricate issue in the Netherlands. Most plans have nowadays more or less explicitly linked the fraction of wage or price inflation that will be compensated to the funding ratio of the plan. Indexation is usually not legally binding though. For that reason the SA focuses on buffers required to cover the solvency risk in nominal claims. Clearly inflation risk is an important risk component however for funds that do offer indexed pensions as well as for plans that simply aim at indexation and want to understand the costs and risks involved in providing indexation, irrespective of any regulatory rules. The SA offers a simple adjustment to take inflation risk into account in the buffer for interest risk S_3. The assumption is that expected inflation increases by 30%, irrespective of the investment horizon and that nominal rates instantaneously adjust accordingly. Subsequently the worst case of the two interest rate scenarios (excluding and including the shock in expected inflation) is to be taken.

The assumption that all inflation expectations move parallel and that real rates are not affected by inflation shocks can easily be avoided by referring to models of the joint distribution of nominal and real interest rates[10]. These models relate the impact of nominal and real interest rate movements to a limited number of factors and can thus also easily be incorporated in SA and ESA.

7. Miscellaneous risk factors.

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

In the SA idiosyncratic credit risks (migration to another rating) are ignored and the changes in credit spreads are treated as a separate risk factor along the lines of the treatment of interest rate risks. Changes in credit spreads are assumed to be uncorrelated with stock returns and interest rate fluctuations.

Pension plans can also have substantial volatility risk due to positions in hedge funds or non-linear derivatives. The SA assumes that these exposures can be translated to a delta-equivalent direct stock market exposure. Volatility risk is addressed in the SA under the heading of stock market risk. Shocks of 25% of the current level of volatility are assumed to occur with a probability of 2.5%. The assumption is made

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[8] In the SA proposed by DNB macro longevity risk is included by requiring an implicit buffer in the (actuarial) estimate of the market value of the liabilities (75% quantile). It would be more natural to include macro longevity risk as a seventh risk factor in (1). For most funds this would reduce the required buffer.
[9] See Hari et. al (2006)
[10] Examples are Campbell and Viceira (2001) en Brennan and Xia (2002)

that worst-case scenarios in returns and in volatility coincide. This is not necessarily the case. A portfolio with stocks and put options is hurt by an extreme negative return but the associated increase in volatility increase the value of the puts. The use of a grid of bivariate scenarios (returns and volatilities) could be used to remedy this problem.

Note also that the SA assumes monotonicity of the mapping from fundamentals to values of assets and liabilities 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 use of the standardized approach. This assumption is not necessarily satisfied e.g. for funds that have exposure to derivatives or hedge funds. Simulation based internal models do not require the monotonicity assumption and will automatically detect the worst case scenario's.

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. Like we argued for the case of derivative positions or hedge funds, the use of an IM seems much more adequate than the use of an SA if concentration and / or operational risks are present.

8. Evaluation

New solvency tests are likely to be promoted or imposed in the years to come by national and international supervisors alike. Risk management in the pensions and life insurance industry will no doubt get new impulses from these models, not unlike the impact of RiskMetrics on risk management of banks in the nineties. In this note we analysed the SA proposed by the Dutch supervisor and extended it to be able to model the distribution of the funding ratio (ESA).

The strength of SA and ESA no doubt lies in the simplicity of the approach. All calculations are of a back-of the envelope nature and can be performed in a simple Excel spread sheet. Simulation approaches are not required. The SA can well take the role of a work-horse model that serves as a benchmark for more elaborate models and can thus mark a major step forward to professional risk management also of smaller pension plans and (life) insurers. Of course such a simple approach to the problem has a number of shortcomings. A number of them were already listed above: some parameters are assigned non-standard values, macro longevity risk is ignored, inflation risk is not incorporated in a very satisfactory way, interest rate fluctuations are restricted to parallel movements in the term structure only etc. Most of these limitations can be remedied in slightly generalized versions of the same model.

Alternatively risk in a pension plan can of course be measured using an simulation model that is tailor-made for the specific fund. These models can be much more general and can avoid many of the simplifying assumptions made in the SA. Simulation models also have a potentially very important drawback relative to standardized models. If the internal models are insufficiently understood and evaluated by independent experts, internal models can easily carry a lot of model risk in that misspecification of the model strongly affects risk assessments. Explicit comparison of all results generated by an simulation model with a well understood standard model like the SA is a tool to mitigate model risks. As a side effect of this the limitations of the SA will become more transparent and the SA can be updated and refined.

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