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Introduction [1] [2]

By strategic use of options, I refer to employing options or dynamic trading strategies to structurally obtain non-linear exposures to risky assets. Appropriate dynamic strategies enable investors to shape the return characteristics of their investments in such a way that they match better with their long-term aspirations. In the case of pension funds, these long-term aspirations could pertain to paying out indexed benefit payments at acceptable funding costs. In this paper, I shall investigate to what extent pension funds can benefit from the strategic use of options [3].
First, we shall discuss Frijns (2005) in which he compares two investment policies in a pragmatic, empirical way. Then we shall extend his analysis by proposing and analysing a third policy in which the exposure to developed equity markets is obtained through options.
Secondly, we shall review academic literature in which optimal exposures to risky assets are derived under various assumptions on investment preferences, market efficiency and equilibrium settings.

Three long-term pension fund investment strategies

In January of this year, the Dutch Central Bank (DNB) organized a farewell symposium for Rein van Dam. On that occasion, Jean Frijns delivered a speech (Frijns 2005) in which he made a further contribution to the present discussion in the Netherlands regarding the supervision of pension funds by DNB. He discussed the trade-off between long-term real aspirations of pension funds on one hand and short-term nominal risk constraints imposed by the regulator on the other hand. Table 1 summarizes Frijns' reasoning.

	Long- term real objectives	*Long- term real objectives with short-term nominal solvency constraints*
Strategy	Long- Term Risk- Taking (LTRT) - Well diversified investment portfolio with substantial exposure to equity markets - Hedge against inflation and changes in real interest rates	LTRT + Interest Rate Swaps - Dynamic strategy to manage interest rate risk - Change benefit formulae: Nominal Defined Benefit + "for profits" top-up
Draw-backs	- Inflation hedges are expensive and availability is limited - Risk of passing on an unpaid bill to future generations	- LTRT + IRS does not protect against inflation risk - Timing is unfortunate: current expected inflation and interest rates are both at very low levels

Table 1: Two settings with their most appropriate strategy and the arguments against that, taken from Frijns (2005)

After laying out this conceptual framework, Frijns presented an empirical study to compare two investment strategies under each of the two regimes: Long-term Risk-taking (LTRT) and LTRT plus an interest rate swap (LTRT+IRS).

The Long-term Risk-taking asset mix
To be able to fund indexation from investment revenues, one would ideally want to purchase indexed cash-flows that match projected indexed benefit payments. In practice, this is not always possible because costs may be prohibitive. A second best solution then is to hold a well diversified portfolio with a sufficiently high expected return. This calls for a substantial portion of the portfolio to be invested in risky assets. The fixed income part of the portfolio has a relatively low duration because the returns on fixed-income investments with a long duration are a worse hedge against inflation.
In tables 2 and 3, we report LTRT returns based on an asset mix consisting of 50% equities and 50% bonds with a 5-year duration. Table 4 is based on the actual historic asset mixes of ABP, which, on average, have less than 50% exposure to developed equity markets because the risky part of the portfolio is partly invested in other assets that improve diversification.

The Long-term Risk-taking asset mix + Interest Rate Swap
In the presence of short term nominal solvency constraints, the LTRT mix

is very risky because of the mismatch in sensitivity to nominal interest rate changes of the value of the assets and the value of the liabilities. To immunize the funded ratio to nominal interest changes, an interest rate swap (IRS) is added to the LTRT asset mix. Here, the IRS is structured so that the investor pays the short-term interest rate over the value of its assets and receives the long-term interest rate over the value of its assets. The IRS is specified so that the duration of the assets equals that of the liabilities. As a consequence, the funded ratio of the pension fund becomes insensitive to parallel shifts of the yield curve. This mitigates the risk of violating the short-term solvency constraints.

The Dynamic Long-term Risk-taking asset mix

Frijns mentioned the possibility of employing dynamic strategies to reduce downside risk but he did not include a dynamic investment strategy in his empirical example. Here, such a strategy is included and I'll refer to it as Dynamic Long-term Risk-taking (Dyn LTRT).

The Dyn LTRT asset mix is identical to the LTRT asset mix, except for the way in which exposure to developed equity markets is obtained. Every euro that is invested in equities in LTRT is replaced by an investment of:

- 42 cents in a mutual fund that offers a leveraged exposure to equity markets [4]
- 58 cents in a fixed income portfolio with a duration equal to the duration of the liabilities of the pension fund [5].

Due to its leveraged investments, the expected return on the mutual fund is much higher than the expected return on a straightforward investment in equities. It's also riskier. In a portfolio context, however, one should notice that 58% of the assets that used to be invested in equities, are now invested in a virtually risk-free asset: a fixed-income portfolio with a duration equal to that of the liabilities.

The above proportions are chosen such that the average exposure to equity markets in the Dyn LTRT mix is equal to that of the LTRT mix. To gain intuition on the characteristics of Dyn LTRT in comparison with LTRT, consider the case that the return on the fixed income portfolios is 5% and the return on equities equals -50%. Then the return on the LTRT portfolio equals 0.5 * 5% + 0.5 * -50% = -22.5%. Using the relationship in footnote 4, the return on the Dyn LTRT portfolio equals 0.5 * 5% + 0.5 * (0.42 * -82% + 0.58 * 5%) = -13.3%. The Dyn LTRT mix is less vulnerable to equity market crashes whilst offering the same expected return as the LTRT mix. Moreover, it provides a partial hedge against nominal interest rate changes.

A pragmatic empirical analysis

The three asset mixes were analyzed by comparing asset returns and changes in funded ratios

1. under hypothetical shocks in real and nominal interest rates
2. during historical stress months
3. over the period from January 1999 until November 2004.

Scenarios of changes in nominal and real interest rates

Scenario 1: Nominal interest rates rise from 4.5% to 6.5% and real rates rise from 2% to 2.5%

Scenario 2: Nominal interest rates drop from 4.5% to 3.5% and real rates remain at 2%.

	Initial situation		*Scenario 1: rising interest rates*			*Scenario 2: falling interest rates*		
Dur(LN) = 16 Dur(LR) = 18	Interest rate	Funded ratio	Return assets	Return liabilities	Funded ratio	Return assets	Return liabilities	Funded ratio
Nominal world								
LTRT	4.5%	120	-6%	-26%	152	3%	17%	106
LTRT+IRS	4.5%	120	-26%	-26%	120	17%	17%	120
Dyn LTRT	4.5%	120	-18%	-26%	133	11%	17%	114
Real world								
LTRT	2%	76	-6%	-8%	77	3%	0%	79
LTRT+IRS	2%	76	-26%	-8%	61	17%	0%	89
Dyn LTRT	2%	76	-18%	-8%	67	11%	0%	84

Table 2: Comparison of investment strategies under two interest rate scenarios

The difference in changes in funded ratio in Table 2 is caused by the difference in exposure to changes in real and nominal interest rates. Sensitivity to changes in nominal interest rates is smallest for the LTRT mix and largest for the LTRT+IRS mix. When interest rates rise, this leads to greater losses on the LTRT+IRS mix and consequently a relatively poor development of the funded ratio, measured in real terms as well as in nominal terms. Similarly, when nominal interest rates fall, LTRT+IRS does much better than LTRT. In both scenarios, the performance of the Dyn LTRT mix is less extreme than that of the other mixes. This reflects the interest rate sensitivity of the Dyn

LTRT mix being in between that of the LTRT and LTRT+IRS mixes.

Historic Stress Months

	LTRT		*LTRT+IRS*		*Dyn LTRT*	
	Nominal	*Real*	*Nominal*	*Real*	*Nominal*	*Real*
Black Monday (October 1987)	-13%	-7%	-7%	-1%	-11%	-5%
Gulf War (August 1990)	1%	-3%	-3%	-7%	1%	-3%
Russian Crisis (August 1998)	-9%	-7%	-8%	-6%	-7%	-5%
Terrorist attack (September 2001)	-3%	-2%	-4%	-3%	-3%	-2%
Average	-6%	-5%	-6%	-4%	-5%	-4%

Table 3: Asset returns during stress months

The LTRT+IRS mix comes out best over October 1987. Dyn LTRT and LTRT both show better returns than LTRT+IRS in August 1990 and September 2001. In August 1998, Dyn LTRT does best. On average Dyn LTRT comes out best, both in real terms and in nominal terms.

Historic monthly return distributions from January 1999 until November 2004

	LTRT	*LTRT+IRS*	*Dyn LTRT*
Average	0.3%	0.6%	0.5%
Median	0.5%	0.3%	0.5%
Maximum	3.7%	9.5%	4.7%
Minimum	-3.6%	-4.5%	-3.4%
Standard deviation	1.7%	2.6%	1.8%

Table 4: Monthly return statistics over the period January 1999 – November 2004

The LTRT returns in table 4 are based on the actual asset mixes of ABP during this period. LTRT+IRS and Dyn LTRT mixes are defined as described earlier. LTRT+IRS has the highest average return, followed by Dyn LTRT and LTRT. The high average return on LTRT+IRS is caused by the fact that interest rates have fallen in the January 1999 – November 2004 period and LTRT+IRS returns are highly sensitive to interest rate changes. The results on Dyn LTRT differ from the other mixes not just because of a difference in interest rate exposure, but also because exposure to equity markets was obtained through the dynamic asset. The monthly return on the dynamic asset averaged 0.42% compared to 0.04% on the direct equity holding in the LTRT and LTRT+IRS mixes.

Table 4 suggests that Dyn LTRT is the better choice if one selects a policy on mean and standard deviation. Although the mean variance framework is generally unsuitable for analyzing return characteristics of dynamic strategies, one can argue that it doesn't lead to serious mistakes in this case: neither the median return nor the minimum and maximum returns suggest severe asymmetries or fat tails of the return distribution of Dyn LTRT. The same holds for the extreme event analyses in tables 2 and 3.

	Nominal			*Real*		
	LTRT	*LTRT+IRS*	*Dyn LTRT*	*LTRT*	*LTRT+IRS*	*Dyn LTRT*
Average	0.3%	0.5%	0.4%	0.1%	0.4%	0.3%
Median	0.5%	0.7%	0.5%	0.3%	0.2%	0.4%
Maximum	5.3%	3.5%	5.0%	14.0%	13.9%	14.0%
Minimum	-6.5%	-4.0%	-5.5%	-8.2%	-7.3%	-7.4%
Standard deviation	2.8%	1.8%	2.4%	3.6%	3.3%	3.4%

Table 5: Statistics on monthly changes in funded ratio over the period January 1999 – November 2004

We now turn to a comparison of the impact of the choice of an investment policy on the funded ratio. It turns out that the LTRT+IRS mix is hard to beat. That was to be expected because the comparison of results between LTRT+IRS on the one hand and LTRT and Dyn LTRT on the other is dominated by the fact that LTRT+IRS is much more sensitive to changes in long interest rates which fell sharply during the backtest period. Despite the modest exposure to changes in interest rates of Dyn LTRT, funded ratios under Dyn LTRT behave almost as well as under LTRT+IRS. This indicates that dynamic policies along these lines may be suitable to combine long-term risk-taking with the elimination of unacceptable risks.

Theoretical background

Financial theory assumes that investors select their portfolio of payoffs so that it maximizes their expected utility, given their perceived probability distribution of future states of the world and prices at which they can buy state-dependent payoffs.

Here, I shall focus on three papers. The interested reader could use these as a starting point for further study.
Cass and Stiglitz (1970) show that it cannot be optimal for an investor to have a linear exposure to a risky asset, unless the investor has a HARA utility function with a specific level of risk aversion.
Carr and Madan (2001) conclude that optimal payoffs are always non-linear, except in cases where investors have a HARA utility function and a market view that agrees with what's reflected by market prices of options. They also show that non-linear exposures are optimal in equilibrium settings. In those cases securities prices are no longer given. Instead, they follow from investors maximizing expected utility in combination with an equilibrium condition. This is relevant because these results indicate that non-linear exposures are optimal, even if potential market impact is taken into account.
Franke, Stapleton and Subramanyam (1998) define background risk as financial risk due to non-tradable exposures. They argue that investors can be natural counterparties to eachother in trading non-linear exposures if they are exposed to different levels of background risk. They prove, under mild assumptions, that the higher the level of background risk to which an investor is exposed, the more convex his optimal payoff function is. Differences in background levels can imply equilibriums in which the optimal payoff function of one investor is concave and the optimal payoff function of another investor is convex. The former would then be the protection seller and the latter the protection buyer.

Concluding remarks

The empirical analyses show that hedging interest rate risks may be the safe thing to do from the perspective of managing nominal funded ratios. However, for pension funds with the ambition of paying out indexed benefit payments, it is important to manage the funded ratio measured in real terms. For these investors, it would turn out to be costly if they hedge their nominal interest rate risk and interest rates develop along the lines of Frijns' Scenario 1. Presently, many investors perceive interest rates and inflation rates to be low and funded levels of Dutch pension funds are, in many cases, close to the minimum funded ratios required by the regulator. It may be advisable to follow a long-term risk-taking policy combined with protective strategies that eliminate the risk of unacceptable losses. Both financial theory and the empirical analyses in this paper indicate that strategic employment of dynamic strategies can contribute to this end. The Dynamic Long-term Risk-taking policy that was proposed in this paper may serve as a starting point to design such policies for investors with medium to large sized portfolios.

Literature

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Notes

1] The views expressed in this paper are my personal views and do not necessarily reflect those of ABN AMRO Asset Management.

2] I am grateful to Roderick Molenaar of ABP Investments for providing me with the numerical results presented in tables 2, 3, 4 and 5 and to Tom Steenkamp and Bart Oldenkamp for useful comments on an earlier draft of this paper.

3] In this paper "options" and "dynamic trading strategies" are used interchangeably because both are merely means to obtain non-linear exposures to a risky asset. The choice of using options or executing a dynamic trading strategy is a make-or-buy decision, the analysis of which is beyond the scope of this paper.

4] The monthly return on the leveraged investment in equities has been modeled as: R(leveraged equity) = exp(-0.0037 + 2.4470 * return(equities)) – 1 in which R(leveraged equities) is the arithmetic monthly return on the mutual fund and r(equities) is the monthly logreturn on equity markets. This reflects the observed relationship over the period June 1996-December 2004 between the return on equity markets and the realized returns on a live mutual fund that offers systematic leveraged exposure to equity markets with a limited liability.

5] This fixed income investment consists of the fixed income portfolio that is held in the LTRT mix and an interest rate swap to match its duration with that of the liabilities.