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Working Paper

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HOW DERIVATIVES CAN HELP SOLVE THE PENSION FUND CRISIS

ABSTRACT

In this paper we use a scenario-based ALM model to study the effects on the risk-return profile of defined benefit pension funds from including options in the pension fund portfolio. Our results show that properly constructed option strategies can add substantial value to pension fund management. The results are robust with respect to variations in horizon, equity risk premium and volatility assumptions. The optimal strategy, however, should be determined in an asset-liability context and not ad hoc, as the intuitively most appealing strategies are not necessarily the most effective. In addition, we find that different types of funds may require significantly different option strategies. What works well for one fund may be less effective or even counter-productive for another. Overall, *incorporating options appears an efficient way of improving long-term pension fund health and therefore the sustainability of defined benefit pension schemes.*

1. INTRODUCTION

Pension funds worldwide are in big trouble. Unexpected increases in life expectancy, changing accounting rules, contribution holidays/reductions, low interest rates and very poor equity market returns have led to a steep fall in funding levels. Especially UK pension funds, which always have had a relatively high equity allocation, have been hit hard, with aggregate shortfalls reported to be in excess of £200 billion. Of course, this has a whole range of serious consequences. According to the National Association of Pension Funds, the rate of final salary scheme closures is increasing rapidly, with more than 40% of companies in the UK, including household names such as Barclays, Marks & Spencer, and Tesco, closing their schemes in the past 12 months. As a result, fewer than one in five employers in the UK currently offer a final salary pension scheme to new staff. In addition, many companies have started to substantially increase their contributions to maintain funding levels. It was recently reported that British Telecom shall be making top-up payments to its pension fund in the amount of £232m per year for the next 15 years. In the US, several giants also have had to make multi-billion dollar payments into their pension funds recently (IBM $4 billion in 2002 and GM $1.2 billion in 2003 for example), with many others following suit. In Continental Europe the situation is not different. Rabobank in The Netherlands (total contributions of Euro 1.2 billion in 2001-2003) and Siemens in Germany (Euro 2.6 billion over 2001-2003) are just two out of many companies that have had to make very substantial top-up payments lately. It appears that, under current pension fund management practices, pension funds are highly pro-cyclical.

In addition to the above, pension funds are also confronted with the fact that the asset classes traditionally deployed to generate excess return over the risk-free rate are now perceived to contain less premium and more risk than was the case in the last two decades. Recent studies have shed new light on the long accepted equity risk premium level of 4-5%. This historical estimate appears to be biased by measurement and estimation errors and some researchers claim that the actual equity risk premium over the past century might have been closer to 3%, with little reason for the expected future risk premium to be any higher than that.[1] To compensate for the lower expected return on equity and to stay on the required growth path, pension funds will have to

expand their equity investments. Increased risk aversion and the terrible performance of the world's stock markets, however, will point exactly the other way.[2]

Several obvious solutions to the above problems have been suggested in the popular and professional press. One is to require sponsors to increase their contributions. Another is to reduce pensions. These alternatives are currently being discussed at great length. Little is being said, however, about the investment process that links contributions and pensions. Although the area of pension fund investment management is inherently complex, it seems not more than prudent to first investigate whether pension fund health can be improved by changing the way in which pension funds invest before calling out for a rise in contributions and/or the slashing of pension rights. In essence, this is also the message of the Myners (2001) Report that caused quite a stir in the UK in 2001.

There are several reasons to assume that pension fund investment management can be significantly improved upon. First, many pension funds are very return-oriented and hire active outside managers to do their actual investing in an attempt to pick up as much 'alpha' as possible. These managers charge substantial fees and so do the consultants that help to select and evaluate these managers. There is overwhelming academic evidence, however, that active management only adds costs, not value. This means that in aggregate pension funds pay billions in fees every year while getting inferior performance in return. Second, many pension funds stubbornly stick to the traditional asset classes of (international) fixed income, equity and real estate. However, there is evidence of significant changes in the relationship between these asset classes, which may seriously reduce the diversification benefits that can be derived from them. International equity markets for example are becoming more and more correlated (geographically as well as sector wise), strongly reducing the benefits of international diversification.[3]

Fortunately, developments in the global capital markets have not been all bad. Over the last two decades a whole new range of investment alternatives has emerged. Many of these appear to be only weakly correlated with traditional asset classes and therefore offer significant diversification potential. This includes not only commodities, hedge funds, managed futures, and private equity, but also the

possibility to invest in previously non-investable risks such as weather, pure credit, catastrophes, etc. In addition, the last two decades have seen an explosion in the availability of risk management products that allow investors to modify the risk-return profile of their portfolio with great ease. Nowadays, all major investment and commercial banks employ large derivatives teams, able to structure tailor-made risk management solutions to virtually any problem.

The obvious question that arises then is whether and how pension funds can use these new products to their advantage. Are they, from a pension fund perspective, just frivolities with little or no practical value or can their proper use make a substantial contribution to pension fund management? In order to appreciate the benefits and pitfalls of these products in full, they of course have to be incorporated in an asset and liability management (ALM) framework. Asset-only analysis – an evaluation method still very often applied – does not make sense considering the risks contained in a pension fund, i.e. the risk of the asset value falling short of the value of the pension liabilities and the severe impact on contribution rates. Correlations between assets and liabilities and the long-term dynamics of a pension fund therefore play a role at least as important as the correlation between the different assets classes.

In this paper we use a scenario-based pension fund ALM model to study the impact of a number of option strategies on the risk-return profile of a defined benefit ('DB' or 'final salary') pension fund. Our focus will be on the reduction of extreme risks, i.e. the risk of prolonged and/or severe underfunding, resulting in extremely high contribution rates. Even if contributions are fully paid by the employer, such scenarios represent a genuine risk to the fund beneficiaries as the solidarity between the stakeholders in the scheme may easily become fragile and break down. Severe underfunding will have a strong impact on the competitive position of the parent company and thereby provide sponsoring employers with a strong incentive to search for less costly alternatives. Most pension schemes allow employers several ways out when things go wrong and many employers have proven to be quite eager to take the opportunity as soon as it arises. This is not only true for countries such as the UK, where according to OPRA over the last 10 years alone around 58,000 defined benefit schemes have been wound up, but also for countries where there is a much stronger track record of employer support to DB schemes, such as The Netherlands for

example. In general, the extreme risks in a DB scheme are absorbed by the beneficiaries, not the employer.

Although we concentrate on defined benefit funds, it is important to note that our results are equally important for the management of defined contribution ('DC' or 'money purchase') funds. Although different in concept, the actual differences between defined benefit and defined contribution are much smaller than often thought. In both cases, the goal is to provide beneficiaries with a decent old age. In both cases, the risk of underfunding and/or high contributions eventually lies with the beneficiaries. This is clear in defined contribution schemes but, as argued above, it is also true for defined benefit schemes.

The paper proceeds as follows. In the next section we briefly introduce the general ALM framework that we will use and its underlying assumptions, while in section 3 we show why, especially given the current situation, pensions funds cannot ignore to invest in risky assets if they want to stay on their required growth path. In section 4 we introduce options into the asset mix and investigate how this changes the probability of high contributions. Since options offer non-linear payoff profiles they can help to reduce extreme risks while at the same time retaining the more bearable risks to secure (at least some of) the risk premium on risky assets. In this section it also becomes clear that the risk-impact of the various option strategies depends heavily on the characteristics of the pension fund in question. Since our analysis necessarily has to rely on a number of assumptions, section 5 contains a further sensitivity analysis of our results. Section 6 concludes.

2. THE ALM MODEL

Investigating the full impact of option strategies and investment in new asset classes on a pension fund's risk profile requires a realistic ALM model as the core tool of analysis. Discussion of the full details of the ALM model used in this paper (the basic version of which is well known in the pension fund industry and in use by a large number of pension funds to support their actual decision-making), however, would take too much space and cloud the real issues under investigation. We therefore limit

ourselves to a brief description of the building blocks that make up the ALM model. More details can be found in Boender et al. (1998).

An ALM model typically consists of a number of building blocks or modules, each dealing with a different aspect of the fund management decision:

(1) **The external economy -** Generates yield curves, the returns on various other asset classes, inflation, etc.

(2) **The actuarial liability structure** - Generates future obligations, partly as a function of inflation and possibly in combination with the funding level as a conditioning variable for indexation.

(3) **The asset structure** – Generates the actual asset value as a function of the external economy and investment and rebalancing rules related to contributions, payouts, asset developments, dividends, coupon reinvestment aspects, etc.

(4) **The policy instruments** – This includes the contribution rate and refunding policy, the indexation policies for active and inactive members, the pension policies (pension age, final wage versus average wage, etc), and asset allocation decisions, all possibly as a function of the funding level and one or more other state variables.

(5) **Objective function** – This includes the various risk and return variables of interest, characterized by type (contribution rate, funding level, etc), level and horizon.

In what follows we discuss the above modules (1)-(5) in some more detail.

The External Economy

To study the impact of different decisions on future pension fund performance we have to generate scenarios for the external economy. The scenario-generating model used in this study is a Vector Autoregressive (VA) model, estimated on end-of-year historical data over the period 1970 – 2002. The model generates stochastic paths for

various long and short-term interest rates, with the yield curve subsequently determined using the Nelson-Siegel (1987) curve fitting technique. The model also generates annual returns for global stock indices as well as price and wage inflation, incorporating mean-reversion and the correlations between all variables involved. Option prices are based on the values of the underlying reference indices and risk-free interest rates as generated by the model. We account for the term structure of implied volatility as well as 'smile' effects by working with a 'volatility surface' defined as a spread over the volatilities of the underlying reference indices generated by the model.[4] Although the model itself is capable of handling a large number of different asset classes, in this study, to avoid unnecessary complication, the basic asset mix is constrained to a combination of global equities (taken to be the MSCI equities world index) and global bonds (MSCI bond world index).

<< Insert Table 1 >>

It is important to note that although initially all model parameters are historically estimated, the actual parameter values used for the average short and long term interest rates, equity risk premium, and inflation rate are based on contemporary subjective inputs. The equity risk premium for example is fixed at 3% (geometric mean), in line with a number of recent publications on this subject. The averages and volatilities of some of the key variables in the model are shown in Table 1.

The Actuarial Liability Structure

More than 90% of the workforce in The Netherlands is covered by occupational pension schemes, which are dominated by defined benefit plans (95%). Ultimo 2002, pension assets in The Netherlands were estimated at 112% of GDP, compared to 66% for the UK.[5] This explains why 16 of the 50 largest European occupational pension plans are Dutch. The actuarial model used in this study is therefore based on representative pension funds in The Netherlands.

Our analysis takes a going-concern perspective. We simulate a pension fund over a 5 year and 10-year horizon with not only existing participants contributing annual rates in return for future pension rights, but also with existing employees exiting and new

employees entering the fund, based on an empirically estimated Markov-chain process. The latter process describes how from one year to the other a participant can move from one state to another (e.g. from active employee to retiree or from retiree to deceased participant) and with what probability. The going concern approach closely resembles the situation in a real-life pension fund. The alternative is to evaluate pension funds from a so-called 'liquidation perspective', in which case no new entrants and contributions are assumed. This, however, is inconsistent with normal pension fund management and only applies in a small number of cases where a fund is closed due to, for example, default of the parent company.

More specifically, we make the following assumptions. At initiation, 73% of the members are in-active (of which 28% retirees), representing 67% of the liabilities. At the start of the analysis, the duration of the liabilities is approximately 12.6 years. The going-concern structure, however, is such that these parameters do not change very much over the period of analysis. After 10 years, for example, the duration of the fund liabilities is still 12.2 years.

Around Europe and in the US, the value of pension liabilities is calculated in different ways. In the Netherlands, liability value is based on a 4% yield curve assumption. This curve is an approximation of the nominal curve in case no indexation is assumed and an approximation of the real interest rate curve in case full indexation is assumed (and something in the middle in case of conditional indexation). In other countries, such as the US (FASB) and the UK (FRS17), there is a tendency towards the use of the AA corporate bond curve as the basis for valuation. In the long run this approach is expected to be adopted in continental Europe as well. We conducted our analysis using both the 4% curve and the AA curve, but this did not yield significantly different conclusions on the effectiveness of the strategies studied. The results presented are based on the 4%-method.

The Asset Structure

The fund's assets are fully invested in worldwide bond and equity indices and – for the derivatives part – OTC equity derivatives as defined in the next section. All assets (including non-expired options) are valued annually at market prices. The strategies are fully rebalanced to their target levels once a year. Rebalancing takes place after

contributions are collected and pensions paid. The actual option strategies will be explained in more detail in section 4.

The Policy Instruments

We have four policy instruments available: the contribution rate, price/wage indexation, pension and asset allocation policy. The first two are linked to the funding level, which is simply defined as the asset value at time *t* divided by the liability value at time *t*. No accounting reserves are assumed on either asset or liability balance sheet items. The contribution rate policy is based on a state-dependent contribution with the funding level and the contribution rate in the previous year as the determinants of the exact level of the contribution rate. No distinction is made between the employers' stake in the contribution rate and the employees' stake, since this is not relevant for the analysis. The indexation of pensions is assumed to be conditional on the funding level. No indexation is granted if the funding level is below 100%. If the funding level is above 100% pensions are indexed with wage inflation. The pension and asset allocation policy are independent of any state variables.

The Objective function

The decision on the actual balance between risk and long-term costs will depend on the pension fund board's attitude towards risk. To maintain a realistic perspective on risk, we avoid using explicit utility functions. Instead, we take the probability of extreme contribution rates as the prime risk variable of interest. A popular alternative risk measure would be the probability of extreme underfunding. Since the main reason why underfunding is undesirable is its impact on contributions, however, we consider a contribution-linked risk measure more appropriate. We will use the following two risk parameters:

1. Probability of one or more years of extreme contribution rates in the next 5 years.
2. Probability of one or more years of extreme contribution rates in the next 10 years

What is considered an extreme contribution rate depends on the basic case of 50% equity, 50% bonds and no options. More specifically, we will refer to a particular

contribution rate as ‘extreme’ if this rate is higher than the rate which in the case without options has a probability of occurrence of X, where X is either 15%, 10% or 5%. In this way changes in contribution rate probabilities resulting from the inclusion of options can directly be interpreted as indicators of the effectiveness of these strategies.

The next question is how and to what extend unacceptable risks can be eliminated? The answer to this question depends heavily on the exact nature of the pension fund in question. We will therefore study two different pension funds. Both pension funds consist of exactly the same participants with the same liabilities, the same indexation policy, etc. The only difference between them lies in their contribution rate policy.

Fund A

This fund has a very extreme funding agreement between its participants that aims at a constant funding level of 100% at the start of every year. When asset returns are lower than the increase in liability value, the fund receives a contribution high enough to restore the funding level to 100%. When asset returns exceed liability growth, the fund gives a refund that equals the asset minus liability value.

Fund B

This fund has a much smoother contribution rate policy, with contributions negatively related to the funding level. If the funding level is below 100% the contribution is 25% of the amount necessary to reach a 100% funding level. For funding levels between 100% and 140% the contribution rate is 2% above last year’s contribution with a maximum of 20%. For funding levels between 140% and 170% the contribution rate is 2% below last year’s contribution rate with a minimum of 0%. For funding levels above 170% the refund is 25% of the amount necessary to achieve a funding level of 170%.

Fund A serves as a reference case for the much more common structure of fund B. Apart from previous year’s performance, past asset performance is irrelevant for fund A’s contribution rate. For fund B on the other hand we can expect to see much larger funding level fluctuations, as well as, in terms of system dynamics, more memory of

past asset performance. This makes the comparison of these two pension funds quite interesting.

3. WHY PENSION FUNDS CAN'T IGNORE EQUITY

Given recent experience, many pension funds have become extremely risk averse and are more likely to decrease than increase their allocation to equity, i.e. move out of equity and into bonds. From a strategic long-term investment perspective, however, this will typically be far from optimal. Also, in practice exactly matching a pension fund's asset mix with its liabilities is simply not feasible and risks inevitably remain. Liabilities are often indexed to wage and/or price inflation. In most countries, however, securities linked to domestic price inflation, let alone wage inflation, are simply not available. In countries where inflation-linked securities do trade, the amounts outstanding as well as secondary market trading volumes are far too low to accommodate pension funds looking to match their assets with their liabilities. The issue gets even more complicated in case of conditional indexation, i.e. funding level dependent inflation compensation.

To get a feel for the risk-return aspects of so-called 'liability-approximating' strategies versus approaches where bonds are partly replaced by risky assets (here for simplicity represented by equity), we looked at a pension fund's required long-term average contribution rate as a function of its equity and bond investments. These long-term averages are contrasted with the risk levels attached to the different investment policies. Table 2 shows the results for mixtures of x% bonds and (100-x)% equity for the two pension funds under investigation, assuming a 10-year horizon. The critical levels for the contribution rate are set in such a way that the accompanying probabilities are 15%, 10% and 5% in the case of 50% equity - 50% bonds.

<< Insert Table 2 >>

Although not completely unexpected, the picture that emerges from Table 2 is very interesting. Increasing the equity allocation yields an increased risk of extremely high contribution rates but at the same time produces a higher expected return on assets

and therefore a lower expected contribution rate in the long run. This makes it clear that for DB pension funds there is a definite trade-off between risk and sustainable cost levels.[6] Minimizing risk by investing in bonds will require unrealistically high contributions and may thereby jeopardise the long-term commitment of the sponsors to the scheme. *To arrive at reasonable pension costs, pension funds will therefore have to take equity risk.* High equity allocations, however, increase extreme risks, which can lead to a situation where contribution rates in some years reach levels that endanger the pension scheme's sustainability. In the next section we offer a possible solution to this problem.

4. INTRODUCING OPTIONS IN THE PORTFOLIO

Pension funds' risk profiles can be restructured in a tailor-made fashion by incorporating financial products with non-linear payoff profiles, i.e. options, into the pension fund portfolio. In order to gain insight in the effectiveness of option strategies it is important to study single contract applications as well as combinations of contracts. Since the evaluation of strategies requires comprehensive analysis, however, the set of possible solutions in this study is confined to four strategies. The first two are very straightforward. The other two are more or less tailor-made for the two pension funds under review to emphasize that what works well for one fund need not necessarily work for another.

All option strategies apply to the equity part of the asset portfolio only. This part exhibits the most volatility and is least correlated with the liability side. It is therefore the most obvious starting point for risk management. The exact way in which the option strategies are executed requires some additional clarification. Options with a time to maturity longer than 1 year are purchased in a layered fashion, i.e. we buy 1/N part 1-year maturity, 1/N part 2-year maturity, etc.[7] Every year, one option expires and a new N-year option is bought/sold, i.e. all option positions roll over. The above technique smoothens the impact of changes in implied volatility and provides additional flexibility with respect to the annual rebalancings, which in practice is highly desirable.

In order to make the four option strategies comparable, they are implemented in such a way as to provide the same long-term expected contribution rate as that in the case of a 50% equity - 50% bonds mix without options.[8] This is done by increasing the equity allocation at the expense of bonds and subsequently adding options on top of that.[9] Put simply, we use the equity risk premium to finance the costs of the options position. Obviously, this will have a very significant impact on the shape of the probability distribution of future contribution rates. Although the average will remain unchanged, we can expect to see more average but less extreme risk.

Strategy 1

The first strategy consists of a long position in a 1-year European composite basket put option. The option is at-the-money initially, which is the most obvious way to obtain protection on the fund's equity investments. The underlying reasoning here is that if the equity part of the portfolio cannot generate a loss and the interest rate part of the portfolio is generating a relatively stable return (given its low volatility compared to equity), in the long run this should generate high enough returns to prevent extreme contribution rates. Unfortunately, with this strategy it is not feasible to maintain the old contribution rate level, i.e. increasing the equity allocation to 100% still only makes up for part of the option premium to be paid. In order to avoid huge equity increases, we will restrict ourselves to a strategy in which only half of the total equity portfolio is protected.

Strategy 2

Since the options in strategy 1 only have one year to maturity, the strategy will exhibit quite some time decay, as a result of which only a small portion of the equity portfolio can be protected. Strategy 2 therefore aims for less time decay and consists of a long position in an at-the-money European composite basket put option with 5 years to maturity on the entire equity portfolio. Of course, the flipside of this strategy's lower costs is that it also provides less risk reduction than strategy 1. Note that in practice extending the maturity of the option beyond 5-7 years will not be possible as (depending on the exact contract specifications) the market becomes progressively less liquid.

Apart from simply buying puts, it is sometimes advocated that pension funds should use zero-cost collars to reduce the risk of their equity investments.[10] The problem, however, is that zero-cost collars only leave a small distance between the upper and lower strike (or contain far out-of-the-money put options). As a result, buying a zero-cost collar is not really different from reducing the equity allocation and investing the proceeds in N-year interest rate products. Since a fund will have to pay a certain bid-ask spread for entering into such collar transactions, it may end up worse than by just selling the equity and investing the proceeds in N-year deposits. Apart from tax, accounting or regulatory considerations, this strategy therefore has little economic significance in an ALM context compared to reducing the equity allocation directly.

Strategy 3 and 4 are designed to fit the typical pension fund situation and are chosen in such a manner that strategy 3 is a better fit for fund A and strategy 4 is a better solution for fund B. The differences between both strategies are kept to a minimum to make their effectiveness explicable.[11]

Strategy 3

This strategy combines downside protection with a small amount of upside-reduction, selling off upside potential to partially finance the downside protection. A 1-year at-the-money put is bought on 50% of the equity volume in the fund. At the same time a 1-year call option with a strike price at 130% is written on 100% of the equity volume.

Strategy 4

This strategy differs from strategy 3 in that, instead of a 1-year at-the-money put on 50% of the equity volume, we purchase a 5-year put with a strike of 125% on 100% of the equity volume. This is in line with the larger dynamics of fund B compared to fund A. The call part is the same as in strategy 3.

<< Insert Table 3 >>

As discussed earlier, every strategy is a mix of equity, options and bonds that is balanced in such a way that the long-term average contribution rate equals that in the case of a 50% equity - 50% bonds mix without options. The strategies including

options are therefore ‘contribution rate neutral’. The initial allocations of all four strategies can be found in Table 3, which shows that keeping the long-term contribution rate at its original level requires a significant increase in the equity allocations.

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<< Insert Table 4 >>

The results of the above four strategies over a 5-year and a 10-year horizon are summarised in Table 4. The table clearly shows how the risk parameter changes as a result of the introduction of options in the portfolio. From Table 4 we can make a number of interesting observations:

- Incorporating simple put strategies does not necessarily reduce the risk of extreme contribution rates. Although for fund A strategy 1 does reduce risk, strategy 2 does not seem to provide much protection. For fund B the results are exactly opposite. The explanation for this lies in the difference in fund dynamics. Fund A doesn’t have any memory of past asset performance, but fund B does. This makes fund B more sensitive to multiple years of bad returns, as a result of which fund B is better protected by longer-term than short-term options. Fund A’s extreme contribution rates only stem from a previous year’s market decline. Short-term options therefore provide more protection than longer-term options, despite their relative costly nature.

- The more sophisticated strategies 3 and 4 seem to be able to improve the funds’ risk profile considerably. The ‘optimal’ strategy, however, clearly depends on the exact structure of the pension fund. This is in line with what we found before for strategies 1 and 2 and is again attributable to the difference in funding dynamics.

- Fund B seems to be able to reduce risks better (with strategy 4) than fund A (with strategy 3). Although there is no simple rule for this, it often appears that the more dynamics contained in a fund, the more options are able to reduce risk. Part of this is due to the effectiveness of longer-term options in these

fund structures, which ensures that the trade off between the annual costs of the options and the risk protection works better than in funds without a large memory function.

- A change in horizon (5 years versus 10 years) does not change the results very much. However, it does show that strategy 1 and 3 are providing slightly more risk reduction in the chosen risk parameters when the horizon is lengthened, while strategy 2 and 4 show exactly the opposite pattern.

5. ROBUSTNESS ANALYSIS

The main critique of ALM modelling is its strong reliance on assumptions. If results are very sensitive to the particular model and input assumptions made, then small changes will have a very large impact on the optimal decision, which defeats the purpose of the analysis. The question therefore is whether the risk reducing character of the option strategies studied here is maintained when the most crucial parameter inputs are changed.

One of the most important parameters in every ALM study is the equity risk premium (relative to the risk-free rate). Before, the equity risk premium was fixed at 3% geometric. Table 5 shows how things would change if we used an equity risk premium of 2% or 4% instead of 3%.

<< Insert Table 5 >>

Overall, the effectiveness of options as a protection tool doesn't seem to suffer much from a change in the equity risk premium. With a lower equity risk premium the risk reducing features of options in the extremes appear to be somewhat better though. This is due to the fact that with a lower equity risk premium the expected growth path of equity is less steep, which in turn implies that the risk of losing money on equity is higher. With equity risk being a larger part of total risk, equity options are more effective in these lower equity risk premium cases.

<< Insert Table 6 >>

With the use of options comes a new parameter (or set of parameters): the bid-ask spread in the options market. Although it is unlikely that global option markets will become much less efficient in the future, periods of low liquidity do occur. Therefore it is important to ensure that (temporary) high bid-ask spreads are not detrimental to the strategies presented. We investigated what would happen if, over the entire period of analysis, the spread between buying and selling options (in terms of implied volatility) would widen with 1%. The results are presented in Table 6, which shows that the bid-ask spread does influence the effectiveness of our strategies, but not in a very substantial way.

It should be emphasized that not all strategies will exhibit the same degree of robustness. If only as a matter of prudence, the above type of analysis will therefore have to be conducted for every new option strategy and pension fund under investigation.

6. CONCLUSIONS

In this paper we have studied the usefulness of options for pension fund management. Our three main conclusions are as follows:

1. **Investing in equity**. Unless a fund is closed for new contributions and sufficiently funded, fully (or largely) investing in bonds will leave a pension fund with an unrealistically high contribution cost burden. Diversifying into equity reduces the required contribution level but at the same time introduces a higher level of risk. Both approaches therefore put the sustainability of DB schemes seriously at risk

2. **The use of options**. Properly constructed option strategies can add substantial value to pension fund management. The optimal strategy, however, should be determined in an asset-liability context and not ad hoc. The intuitively most appealing strategies are not necessarily the best strategies. This is true for both the medium and the longer term.

3. **Importance of fund characteristics**. Different pension funds require significantly different option strategies. What works well for one fund may be less effective or even counter-productive for another. Matters like a fund's funding policy, maturity of its participants, indexation policy, etc. are all of great importance when deciding on the optimal option strategy.

The bottom line of the analysis presented here is that, given the preference of pension funds for a non-linear payoff (a small change in the probability of extreme contribution rates is typically considered much more important than an equal change in the probability of an extremely high refund), *incorporating options appears an efficient way of improving long-term pension fund health and therefore the sustainability of DB schemes.*

Finally, some may say that what is proposed here is unrealistic since the total size of pension assets in the world exceeds the capacity of the world's derivatives markets.

There are a number of reasons to be optimistic, however. First, extreme risks can be reduced substantially without covering all asset classes. In our study we only incorporated options on the equity part of the portfolio. Second, as we also saw before, the options need not cover the entire volume of a certain asset class to be effective. Third, depending on the pension fund structure, different funds should apply different option strategies, i.e. strategies with different strike ranges, long and short positions in different contracts, etc. This will make it easier for the investment banks, commercial banks and insurance companies that typically act as counterparties to these contracts to absorb the accompanying risk. In short, there is no evidence that today's derivatives markets will not be able to absorb a substantial increase in the use of option-based protection strategies by pension funds.

FOOTNOTES

1. See for example Goetzmann and Jorion (1999), Siegel (1999), Jagannathan, McGrattan and Scherbina (2000), Dimson, Marsh and Staunton (2002), or Arnott and Bernstein (2002).

2. This is consistent with a behavioural phenomenon discussed in Slovic (2000), who shows that as soon as the perception of risk of a certain action increases, there will be a strong tendency for the benefits from this action to be perceived lower than before. In periods of higher market risk perception return expectations are therefore likely to be trimmed down, which will amplify investor's tendency to shy away from risky investments.

3. See for example Longin and Solnik (1995, 2001), Campbell, Koedijk and Kofman (2000), or Butler and Joaquin (2000).

4. The spread over the actual volatilities of the underlying reference indices is 2.5% for 1-year and 2.25% for 5-year at-the-money options. For strikes below 100% the spread increases with 2% per 10% lower strike for 1-year options and 1% for 5-year options. For strikes above 100% the spread decreases by 0.25% per 10% higher strike. All implied volatilities for strikes and maturities in between these levels are linearly interpolated. The assumed bid-ask spread ranges from 1% to 2%, depending on the options' strike price and time to maturity.

5. Financial Times, January 13, 2003.

6. Note that this also applies to DC pension funds, but with a much steeper risk-return trade-off due to the absence of risk-sharing between generations.

7. The strike level of the K-year maturity option is set at 100 + K*(X-100)/N) in order to approximate equal 'moneyness'. For example, if X=125 (strike 25%

above spot) for a 5-year option, the 1-year option will have a strike of 100+25/5=105, etc.

8. Keeping the long-term expected contribution rate at the same level as in the case without options may lead to a change in funding level as a result of which situations may not be fully comparable. This doesn't hold for fund A but can be the case for fund B. We have tailored the case for fund B in such a way that the average funding level doesn't change substantially when the option strategies are introduced.

9. Option investments are financed by unwinding part of the equity portfolio and part of the bond portfolio in line with the existing asset allocation. In case the actual option investment is negative, the cash amount is invested in proportion with the equity-bond allocation.

10. A N-year collar is a combination of a short N-year call option with strike X_c and a long N year put option with strike X_p (with $X_c > X_p$ and typically $X_c>100$ and $X_p < 100$). A zero-cost collar is a collar in which the strike prices are set such that the premium received on the call equals the premium required to purchase the puts.

11. For explanatory reasons, the products and combinations discussed here are kept as simple as possible and are not the true optimal solutions. The latter are substantially more complex and less transparent than the strategies discussed here.

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Table 1: Key model parameters VA model.

	Average geometric return	Volatility
MSCI World	8.70%	21.00%
short term interest	4.70%	3.00%
long term interest	5.70%	1.60%
Wage inflation rate	3.30%	2.10%

Table 2: Risk-return results for different asset allocations, horizon 10 years.

Horizon 10 years

		Fund A: direct funding policy				Fund B: Smoothed funding policy			
Bond	Equity	P(CR > 104.5)	P(CR > 112.5)	P(CR > 126.5)	Average CR	P(CR > 32.5)	P(CR > 37)	P(CR > 42)	Average CR
100%	0%	0.30%	0.05%	0.00%	19.15%	0.30%	0.00%	0.00%	18.51%
90%	10%	0.25%	0.00%	0.00%	16.74%	0.75%	0.00%	0.00%	17.91%
80%	20%	0.55%	0.20%	0.00%	14.35%	1.75%	0.35%	0.05%	17.55%
70%	30%	2.45%	1.20%	0.30%	11.96%	5.25%	1.80%	0.40%	17.11%
60%	40%	7.05%	3.80%	1.50%	9.54%	10.20%	5.00%	2.20%	16.31%
50%	50%	15.00%	10.00%	5.00%	7.09%	15.00%	10.00%	5.00%	15.02%
40%	60%	24.60%	19.35%	10.85%	4.62%	19.70%	13.55%	8.80%	13.31%
30%	70%	34.80%	28.50%	19.40%	2.14%	25.45%	18.50%	12.35%	11.28%
20%	80%	45.65%	37.85%	27.95%	-0.36%	29.55%	23.00%	16.90%	8.97%
10%	90%	54.00%	47.25%	35.85%	-2.85%	33.00%	27.55%	21.35%	6.45%
0%	100%	61.80%	55.40%	45.35%	-5.36%	36.05%	31.35%	25.55%	3.76%

Table 3: Initial allocations for different strategies

	Equity	Bonds	Options
No options	50.0%	50.0%	0.0%
Strategy 1	65.5%	32.3%	2.3%
Strategy 2	61.8%	33.3%	5.0%
Strategy 3	69.3%	29.7%	1.0%
Strategy 4	77.2%	13.6%	9.2%

Table 4: Probability of high contribution rates for different strategies

Horizon 5 years

	Fund A: direct funding policy			Fund B: smoothed funding policy		
	P(CR>80.5%)	P(CR>89.5%)	P(CR>106.5%)	P(CR>29%)	P(CR>32%)	P(CR>37%)
No options, 50% B - 50% E.	15.00%	10.00%	5.00%	15.00%	10.00%	5.00%
Strategy 1	10.35%	5.60%	1.10%	14.30%	8.45%	3.60%
Strategy 2	13.00%	8.60%	3.50%	10.30%	3.95%	0.60%
Strategy 3	8.45%	4.95%	0.95%	11.50%	6.60%	2.70%
Strategy 4	10.55%	6.55%	3.40%	2.95%	1.30%	0.05%

Horizon 10 years

	Fund A: direct funding policy			Fund B: smoothed funding policy		
	P(CR>104.5%)	P(CR>112.5%)	P(CR>126.5%)	P(CR>32.5%)	P(CR>37%)	P(CR>42%)
No options, 50% B - 50% E.	15.00%	10.00%	5.00%	15.00%	10.00%	5.00%
Strategy 1	5.75%	2.90%	0.55%	14.55%	7.95%	3.35%
Strategy 2	14.35%	9.85%	4.10%	12.00%	4.50%	1.60%
Strategy 3	4.75%	2.55%	0.35%	10.65%	5.75%	2.05%
Strategy 4	12.55%	8.75%	4.75%	5.30%	1.90%	0.80%

Table 5: Impact of different equity risk premium assumptions, horizon 10 years.

Equity Risk Premium equal to 2% geometric

	Fund A: direct funding policy			Fund B: smoothed funding policy		
	P(CR>107%)	P(CR>114.5%)	P(CR>128.5%)	P(CR>34%)	P(CR>38%)	P(CR>44%)
No options, 50% B - 50% E.	15.00%	10.00%	5.00%	15.00%	10.00%	5.00%
Strategy 1	5.20%	2.70%	0.50%	14.65%	8.70%	2.75%
Strategy 2	13.00%	9.35%	3.80%	9.55%	4.30%	1.20%
Strategy 3	4.40%	2.45%	0.35%	10.40%	5.90%	1.80%
Strategy 4	11.50%	7.70%	4.65%	4.55%	1.85%	0.50%

Equity Risk Premium equal to 4% geometric

	Fund A: direct funding policy			Fund B: smoothed funding policy		
	P(CR>102%)	P(CR>110.5%)	P(CR>124.5%)	P(CR>31%)	P(CR>35%)	P(CR>40%)
No options, 50% B - 50% E.	15.00%	10.00%	5.00%	15.00%	10.00%	5.00%
Strategy 1	6.25%	3.05%	0.60%	14.30%	8.55%	3.75%
Strategy 2	15.55%	10.40%	4.30%	12.75%	5.55%	1.90%
Strategy 3	5.15%	2.60%	0.45%	11.00%	6.15%	2.50%
Strategy 4	13.85%	9.90%	5.15%	6.20%	3.00%	1.25%

Table 6: Impact of higher option bid-ask spread assumption, horizon 10 years.

Put skew increase of 1%

	Fund A: direct funding policy			Fund B: smoothed funding policy		
	P(CR>104.5%)	P(CR>112.5%)	P(CR>126.5%)	P(CR>32.5%)	P(CR>37%)	P(CR>42%)
No options, 50% B - 50% E.	15.00%	10.00%	5.00%	15.00%	10.00%	5.00%
Strategy 1	5.85%	3.05%	0.60%	15.10%	8.45%	3.55%
Strategy 2	14.40%	9.80%	4.10%	12.80%	4.75%	1.75%
Strategy 3	4.90%	2.70%	0.40%	11.15%	5.80%	2.40%
Strategy 4	12.80%	8.80%	4.75%	6.00%	2.35%	1.10%