

Constructing sustainable pensions

This paper presents a three step plan to arrive at a long-term sustainable risk sharing pension system. The approach aims at economically balancing the interests of all stakeholders – actives, retirees, employers – and thus contrasts sharply with the current DB and collective DC systems

BY THEO KOCKEN

The defined benefit (DB) pension system in Northern Europe is in a serious state of flux. The pension funds are maturing and their balance sheet sizes often equal, if not dwarf, the capitalisation of the sponsor. This, in combination with changing accounting rules, has started a trend, especially in the UK, towards individual pension schemes. To a certain extent this is an undesirable development since it is generally agreed that individuals lack the knowledge to implement life-cycle related planning and are subject to behavioural biases. Furthermore, markets are not perfectly offering indexed annuities or longevity products, which are a few of the many virtues of collective risk sharing pension funds.¹

Other countries with collective risk sharing pension funds are not directly moving towards individual pension provisions, but the DB system is changing there as well. Once a solid part of the terms of employment, it is now being converted into a risk sharing concept, with employers, employees and retirees

typically assuming parts of the risks. A clear example is the Dutch pension system, with retirees and actives also assuming parts of the risk, for example by accepting cuts in indexation in case of an insufficient funding ratio.

In these ‘pension deals’, risks are shared but not every stakeholder assumes the same risks. This is understandable (some are better equipped to absorb risks than others) but what is striking is that:

- 1) Hardly any insight exists in the value these risks can take in terms of the objective market value of the embedded options when bought or sold in the market place.²
- 2) The risks, in other words downside sharing, are not compensated. The lack of any kind of explicit compensation agreements may create strong incentives for some groups to retreat as a risk taker.³ This may eventually cause a serious threat to the sustainability of the collective risk sharing pension system.

All in all, pension contracts comprise trillions of euros but hardly give any insight in exact risk levels per stakeholder or entitlements to returns. This makes them, without any doubt, the most curious contracts in the financial world. It is time to analyse this system.

The main focus in this article is to use proper valuation of the embedded options as a tool to get to a more sustainable pension deal that will survive the maturing stage our DB pension funds are evolving into. However, this

1 Many additional advantages, such as intergenerational risk sharing etcetera, can be added to the virtues of DB funds, as well as some drawbacks, such as the homogeneous product offering in a system with a high heterogeneity of participants. This analysis is however left outside the scope of this paper. See Bovenberg, Koijen, Nijman and Teulings (2007) for welfare aspects of the advantages and disadvantages of the current risk sharing pension schemes.

2 Apart from the values attached to the risks each stakeholder assumes, the level of the risks per stakeholder is also relevant. This paper concentrates on the values attached to these risks only (and how to use these values for redesign purposes), in order to set necessary conditions to make a pension fund sustainable. The risk levels that stakeholders face in a pension fund can be absorbed by these stakeholders or mitigated via risk management tools such as derivatives and strategic asset allocations. This subject is extremely complex - bearing in mind regulatory and accounting constraints - and highly important but not part of this paper, that has a focus on the scarcely investigated valuation aspects and its implications for pension fund design.

3 It is sometimes argued that members do not have any choice but to stay in the pension fund as a beneficiary and so are forced to accept e.g. the transfer of wealth. This may be true in the short run, but in the longer term, members may choose for different employers with less disadvantageous pension provisions or even setting up alternative pension systems, as is the case in the Netherlands with respect to a freelancer's collective (AVV).

CUTTING EDGE RISK SHARING

claim valuation concept can prove equally valuable for many other purposes such as in merger and acquisition negotiations or value transfer mechanisms to define how (groups of) participants move from one pension fund to another. Although this article uses valuation only as a building block to construct an alternative pension deal, the same valuation principles can be applied for these alternative purposes.

In order to create a better balance between risk assumption and return entitlements, the next three steps are critical in designing a pension fund that will stand up to the pressures of competing interests:

- Determine the value of the various embedded options that stakeholders write to the pension fund. This is the market value of the risk they assume in the pension fund and so indirectly it equals the amount they implicitly pay to the pension fund (additional to, for instance, regular contribution rates).
- Determine what the tensions are between the different stakeholders in terms of differences in net option values written to the pension fund.
- Determine how to take away these tensions. Not so much by distributing risks more equally among the stakeholders (which would be economically unwise as some parties have much more capacity to assume risks than others) but, for instance, by ensuring the money injected into the system (by writing options) per stakeholder equals the value of the entitlements to the possible surplus. That is, retain risk sharing but eliminate ex-ante wealth distribution between stakeholders.⁴

This article aims to discuss these three steps in a concise manner, based on a few explanatory cases.

Before the embedded option values are analysed, a brief description of some relevant options in pension funds is provided. In DB pension funds, it is interesting to compare the employer's options with the options the beneficiaries, both actives and retirees, write to the pension fund. The main series of embedded options that the risk taking employer writes to the pension fund is the so-called parent guarantee: The guarantee to support the pension fund in case of funding shortfalls. This depends on, among others, the exact trigger levels at which the parent will pay and the paid amounts, as well as the default probability of the parent company over time.

The main options the beneficiaries write to the pension fund are the indexation option and the pension put. The indexation option is the right the pension fund has to waive indexation in case of an insufficient funding level.⁵ This is sometimes implemented as a 'full indexation or no indexation' construction, with only full indexation granted to beneficiaries above a certain threshold level of the funding ratio. The cases applied in this paper assume these kind of 'digital' constructions.⁶ In other cases, a gradually increasing scale of indexation as a function of the funding ratio is agreed by the board members. The 'pension put' is the option on a joint 'default' event: A deficit in the pension fund and at the same time a default of the parent company.

4 This ensures the "pension product" they buy is offered against fair market prices and does not force generations to sponsor other generations. It still enables those who can afford to take more risks assume the risk and those who cannot to lay off the risks. So fair risk sharing instead of risk sharing against indiscriminate prices.

5 The indexation option comes in many forms. For example, in the Netherlands and many continental European countries, cuts in indexation are linked to the funding ratio (as is the case in the example in the text). In the UK, indexation cuts are linked to the inflation level itself (indexation is capped at a certain level, e.g. 2.5% or 5%).

6 The threshold level for the examples in tables 1 and 2 is a nominal funding ratio of 100%. The threshold level used in the example of table 3 is a real funding ratio of 100%. The first threshold level is therefore much lower, but it should be noted that this concerns a final salary system (indexation cut only applies to retirees) with also a parent guarantee. The systems and their risk distributions are not comparable at all and also not meant to be.

7 The correlation between the equity market returns and default probability equals -0.7 in the example, though values closer to 0 do not change the results considerably, as tested as part of the robustness analysis.

8 Alternative techniques exist, such as pricing kernels (also called deflators). See for example Nijman and Kooijen (2006) and De Jong (2005) in a similar context of embedded options for pension funds.

9 This is a strong assumption, since in many cases the "pension deal" is not very well specified. This may hinder valuation considerably but will also create an incentive for gaming and may be another reason for participants to try to escape pension fund membership. This pleads for more explicit pension deals that are easier valued and can convince all beneficiaries that they have a fair deal.

Table 1: Option values as a function of employer's credit rating (in % liability value)

Credit rating employer			
	CCC	BB	AA
Pension put	10.0	3.1	0.3
Indexation option	12.1	11.3	11.0
Parent guarantee	8.7	17.8	21.3

Table 2: Option values as a function of asset mix composition (in % of liability value)

Equity % in total assets			
Type of option	30%	50%	70%
Pension put	2.5	3.1	3.8
Indexation option	12.3	11.3	10.4
Parent guarantee	15.2	17.8	22.7

Such a joint event will imply write-offs of the pension entitlements, which is defined as the 'pay-out' of the embedded option. The value of the option depends on, among others, the assumptions made with respect to default probability as a function of time, recovery rates and correlation between financial markets and the default probability.⁷

Valuing risks as embedded options

Various embedded options in pension funds can be identified and the most relevant types can be explicitly calculated using market-consistent valuation. Embedded options are measured using arbitrage-free option pricing techniques and assuming complete markets.⁸ Furthermore, the assumption is made that the pension fund stakeholders have arranged very explicit contracts (options) between them and the pension fund.⁹ The analysis below is based on different models that are discussed extensively in chapters two, three and four of Kocken (2006) and will not be repeated here.¹⁰ The options are path dependent¹¹ and quite complex, which makes Monte Carlo simulations of market-consistent and arbitrage-free scenarios (taking the expected value under this risk neutral measure) the most appropriate measurement technique.

To get an impression of the values of these options, Table 1 presents some results at an initial funding ratio of 100% and a stylised asset allocation of 50% equity, 50% bonds for three different credit ratings of the underwriting employer.¹²

It is clear that the embedded option values can reach substantial values. The numbers are even more impressive considering that many pension funds have liabilities that equal or even exceed the capitalisation of the parent company.

10 Although elaborating on the valuation models is beyond the scope of this paper, it is interesting to remark that in pension fund economics, models have to be applied that use real and nominal interest rate yield curves, relevant for measuring the (conditionally indexed) liabilities as well as the bonds in the asset mix. The yield curve models used are arbitrage free with respect to their own measure, but an adjustment had to be applied to make them arbitrage free to the same numeraire. This adjustment is based on the change of numeraire principle. See Den Iseger, Potters and Van der Werf (2006) for the specific model used in Curious Contracts and Jarow and Yildirim (2003) for an application in the nominal and real bond markets.

11 The current option value not only depends on the current values of the market variables but also on realized values of the market variables (their "path") in the past.

12 Some other relevant parameters: The duration of the liabilities equals 13.1 and the ratio between the value of the liabilities belonging to the retirees (and "sleepers") and the value of the liabilities belonging to the actives is close to 3, implying a mature pension fund (though observed quite frequently in practice). The correlation between equity and bonds in this model equals 0.1. See Kocken (2006) for full details.

Table 3: Some embedded option values in a CDC pension fund (in % of liability value)

Asset volatility		
Type of option	4%	17%
Indexation option retirees	7.8	10.9
Indexation option actives	15.9	29.5
Pension put actives	1.6	17.6

Table 4: Participation values for retirees and actives as function of asset volatility

Asset volatility	Participation percentage retirees	Participation percentage actives
4	74.4%	118.2%
10	57.6%	130.1%
17	44.4%	139.5%

These option values also depend heavily on other parameters, one of which is composition (and so the volatility) of the asset mix. Table 2 provides some insight into the impact of asset allocation on the embedded option values.¹³

Although only a limited set of outcomes is presented, it already reveals very interesting patterns. For example, increased levels of risk taking increase the value of the parent guarantee as well as the pension put with almost the same proportion.¹⁴ However, the indexation option sees its value shrinking as a function of higher volatility. This latter – slightly counterintuitive – phenomenon is explained by the fact that in case of a low funding ratio, more volatility increases the likelihood of avoiding indexation cuts. In other words, in case the funding ratio is such that no indexation is granted, the only way to improve this situation is by getting to a higher funding ratio, which is more likely to be achieved with high volatility than with low volatility (without the possibility of any more losses in terms of more indexation cuts, since indexation is already reduced to its lowest level, zero). In more option related terminology: The vega value of the indexation option is negative in case of a low funding ratio.¹⁵

Another interesting analysis is what the values of the various options are in a collective defined contribution (CDC) situation, that is, in the context of a pension fund without an employer as a risk taker. In these situations, only the active members and the retirees assume the risks, with the sponsor exclusively acting as a fixed contribution payer. This is actually a kind of mutual saving plan, representing a situation already de facto applicable to many industry-wide pension funds and corporate pension funds. In some countries such as the Netherlands, some DB funds have even explicitly converted to such a CDC system.

13 The asset allocation is represented by percentage equity versus percentage bonds in this stylised example. The credit rating of the sponsor is BB. 14 It is also interesting to note that institutes such as the Pension Benefit Guarantee Corporation (PBGC) in the US and the Pension Protection Fund (PPF) in the UK are writing the pension put. Not the retirees and the employees, who are however writing an option on the joint event of default of the parent company, default of the protection fund and a deficit in the pension fund (which is unfortunately not an unlikely event as the PBGC case has proven). Both credit rating and asset composition have a huge impact on the risk values these protection funds assume. This methodology makes these values explicit. The values differ from the contributions both for the UK and the US since these contributions are not truly risk based.

15 And, very typical for these kind of “digital” options, positive in case of a very high funding ratio.

16 Indexation is waived in the model applied, not only for retirees but also for actives. In contrast to a final salary system, this is feasible (and applied in practice) in an average career salary system.

This situation shifts the risk picture quite dramatically. The active members in a CDC scheme tend to assume far more risks than the retirees. First of all, because their indexation option value can be much higher due to the longer duration of the actives’ indexation contracts¹⁶; and secondly because they are most likely also assume the risk of nominal pension write-offs.¹⁷ In these kinds of models, many parameters are of importance, especially the ratio of the value of the liabilities belonging to the retirees and the value of the liabilities belonging to the actives. This is the maturity ratio, but would more appropriately be referred to as the ‘generational leverage’. This generational leverage will dominate the risk situations in pension funds five to 10 years from now and deserves much better understanding than currently is the case. In Table 3, some values are shown in cases of extremely low and high asset volatility.¹⁸

Recognising tensions in the pension system

Knowing the value of the embedded options generates new applications in many different ways. For example, the sensitivity of these options to market variables can be determined, which makes it a very useful tool in hedging pension fund risk. Furthermore, the options have a certain sensitivity to volatility. For some parties, it may be advantageous to increase the volatility of the pension fund, for others it may be more profitable to reduce volatility. This implies that conflicting incentives can be revealed via better understanding of the nature and quantitative characteristics of the embedded options.

The most straightforward application however involves using the knowledge of which stakeholder writes what amount to the pension fund. This reveals implicitly how much stakeholders inject into the pension fund. If these values differ too much between stakeholders, this may cause tensions if nothing is granted in return as compensation for taking these risks.¹⁹ In these cases, the pension system may very well be non-sustainable in the long run. Therefore, a fix should be made that reduces these tensions, based on the knowledge of the values of the various options.

Returning to the example of the CDC contract in the Netherlands (Table 3), it is clear that the actives bear far more risks. This is economically sensible because they have much more human capital to cushion these risks than the retirees. But since there are no clear agreements on who is entitled to the upside in the current pension system²⁰ – so that these entitlements should best be assumed absent in these cases – there seems to be a redistribution of wealth from the active members to the retirees. This redistribution sometimes involves 30% or more of the value of the liabilities. This situation may trigger the actives to retreat as a risk taker from the pension fund. This is not a void warning, since exactly the same asymmetric risk-return profile triggered the employers to retreat as risk taker in many pension funds in the UK and increasingly in continental Europe as well.

17 It may be argued that in case of a funding shortfall (even after indexation cuts) both retirees and actives will have to incur a write-off in the pension entitlements. But in the practical application of a Collective DC, it is very likely that during the first few (or many) years after a shortfall, attempts will be made to improve the funding ratio e.g. by increasing the contribution rates of the actives. This is factually equal to transferring the loss to the actives. As time goes by in this deficit situation, the retirees receive their entitlements as payments and the remaining deficit will rest predominantly on the actives’ shoulders.

18 The maturity ratio in this case equals 0.71, much lower than in the previous case. This is chosen in order to ensure that the probability that the retirees will have write-offs on their nominal rights is close to 0. The initial real funding ratio equals 100. The asset volatility is expressed in percentages instead of an indirect equity/bond allocation as in the previous case. This is due to the different, more stylised model set up, avoiding a complex mix of normal and lognormal asset components. The volatility levels belong to a very low equity allocation (say 0-10%) and a very high equity allocation (80-100%) and are just meant to show the extremes of the corresponding option values.

19 See table 3, which clearly reveals that actives assume much more risk (in the specific case) than retirees without receiving proportionally more upside (which is not specified)

20 Apart from a small group of pension funds that did make very explicit agreements on surplus entitlements.

Reduce tensions by redesign

To avoid large redistributions of wealth between stakeholders leading to the demise of collective risk sharing pension funds, only one additional component is necessary. As mentioned before, 'equal risk sharing' is certainly not a prerequisite for retaining risk sharing pension funds, since some stakeholders are naturally more able to absorb risks than others. What is, however, a necessary condition for sustainable pension risk sharing is that the risk takers should be rewarded for their risk. The contract has to be made 'complete' in the sense that it reflects the same risk-return trade-off that is also present in, for example, other products offered in the financial markets. For most pension funds, this does not apply at all, since the obligations to pay into the pension fund in cases of adverse situations are often at least partially specified, but upside entitlements are usually not or to a much lesser extent.

This incompleteness can be repaired in many ways. One important class of solutions is to grant clear entitlements to potential surpluses in proportion to the value of the risks, as expressed in terms of embedded option values. In other words, ex-post but not ex-ante wealth distribution.

Several possibilities to engineer such a balanced pension fund can be provided. In case of the CDC example above²¹, one construction is to give retirees, who may assume some limited risk but do not act as the residual risk takers, some potential in the upside but only partially. This can be put into practice, for example, by giving the retirees an increase in their liabilities when a surplus arises, but not in 100% proportion to that surplus. A larger share will then go to the actives, who also assumed the largest residual part of the risks. This can be set up in such a way that all upside sharing is well-balanced in proportion to the risk taking and is thus in line with how these risk-returns would trade in the market.

The participation levels depend on the volatility of the assets, since this is a crucial determinant for the value of the various embedded options.²² Furthermore they depend on the maturity ratio of the pension fund.²³

Table 4 provides an example of the participation levels that, if granted to the retirees and the actives as compensation for assuming the risks they assume, would exactly offset the value of the options they have written. In other words, they get upside value equal to their downside risk value. The participation level is a percentage that gives the increase in the entitlements per group (retirees and actives) as a percentage of the change in funding ratio.²⁴

A participation level of 57.6% for the retirees, in case of an asset volatility of 10%, implies that if the funding ratio reaches 140%, the retirees' entitlements are 57.6% of 40% = 23% higher than the original entitlements. For the actives, their entitlements grow with 130.1% of 40% is 52%. So the actives have a kind of leverage, which is fair since they also have leveraged risk due to only limited risk absorption by the retirees.

It can be shown mathematically that in the case above, the value of the actives' downside options (indexation option actives and pension put actives)

equals the surplus value minus the retirees' participation option. That is, it equals the value of the upside the actives have been granted. The contract can be engineered in such a way that both the retirees are balanced in upside and downside values as well as the actives. No transfer of wealth from one generation to another takes place ex-ante. This does not imply the elimination of risk sharing between generations. After all, by assuming more risks ex-post, younger generations may pay more to the pension fund and so support the retirees in an economic downturn. But they may also receive more in economically favourable situations. Risk sharing remains, but at fair market prices. That is quite a step forward compared to the current situation, that has revealed or might soon reveal its unfairness to many players such as employers and actives.

Conclusion

To recap, I have the following suggestions for arriving at a situation in which collective saving plans can survive as stable financial institutions with substantial added value to society:

- Make the differences in risk per stakeholder transparent – employer, employee and retiree – by valuing the embedded options created within the risk sharing pension fund.
- Ensure risk sharing remains in the pension fund, and differentiation of risks per group of stakeholders can and should be accepted. Stakeholders should assume risks taking into account, among other things, their human capital.
- Risks have to be transferred at fair market prices, that is, with upside sharing in line with risk absorption. In economic terms: Ex-post redistribution of wealth is possible, but ex-ante no wealth redistribution should take place within a pension fund.

The added value of collective, risk sharing pension funds is that products can be offered that cannot be bought easily in financial markets, such as indexed pensions (especially in large volumes and for domestic inflation) and longevity risk. These aspects make risk sharing pension funds unique and efficient instruments in today's financial world, but they need extensive redesign. Otherwise the system will collapse under the increasing weight of our aging society and the decreasing support from the retreating employer.

Theo Kocken is founding partner and CEO of Cardano and recently wrote the book "Curious Contracts. Pension Fund Redesign for the Future" that provides a mathematically and economically-argued elaboration of many of the topics discussed in this paper. This book can be ordered free of charge at www.cardano.com. t.kocken@cardano.com

²¹ The same methodology as applied in the example in this paragraph can be applied to a corporate pension fund with the employer still in the role of the (partial) risk taker. Making more explicit agreements about the upside sharing (if not obstructed by e.g. pension or tax laws etcetera) may provide incentives to employers not to retreat from their risk taking role.

²² The indexation option is a digital type option; the participation is a call option on the funding ratio. The digital (indexation) option is less sensitive to an increase in volatility than the participation (call) option. This implies that with higher volatility, less call (participation) is granted to the retirees to balance the value of these two options.

²³ This ratio of the value of the entitlements of the retirees and the value of the entitlements of the actives is 0.71 in this example.

²⁴ So these percentages will be allocated between the retirees and the actives until run-off of the retirees. After the current group retirees are gone, the actives simply receive 100% upside of the remaining residual value. This abstract model does not assume new entrants, which was chosen deliberately in order not to get confused with the discussion that "tensions are not relevant because the new generations will assume all the risks". Since new generations tend to be a smaller and smaller population in maturing pension funds (a non-steady state situation, so to speak), this argument is weak and no new entrants is the most extreme case to illustrate the situation.

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