Original Article

Personal longevity risk: Defined contribution pensions and the introduction of an 'equilibrium retirement age'

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ABSTRACT Madsen and Tans address longevity protection for people with Defined Contribution (DC) plans, focusing on variable retirement. The authors introduce the concept of an 'Equilibrium Retirement Age' and show how this increases as life expectancy rises. The authors demonstrate how an individual can achieve equilibrium between capital accumulated through work and capital required in retirement. They derive a closed-form formula for a simplified version of the equilibrium challenge and show how this can provide insight into the trade-offs a DC plan participant faces.

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INTRODUCTION

In recent years, ageing populations have been recognised as one of the key threats to pension systems around the world. As people continue to live longer and as the proportion of retired to working people increases, both pay-as-you-go and funded pension systems will suffer.

Unsurprisingly, companies with Defined Benefit (DB) pension plans have paid increasing attention to rising longevity over the past few years, as rising life expectancy directly affects the

funding costs of DB pension funds. As rising longevity has no direct effect on the funding costs of Defined Contribution (DC) plans, one might be forgiven for thinking that longevity is not so much of an issue for DC plans. This, however, is categorically not the case.

Both DB and DC plans are intended to provide individuals with sufficient financial means to be able to retire and to maintain a certain (and adequate) standard of living throughout retirement. With DC plans, however, the risks of the pension contract are borne by the individual. In other words, under the DC system, the individuals concerned need to balance the savings they make

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over the course of their working life with the cash flows they require throughout their retirement. This balancing act is clearly affected considerably by increasing longevity.

As people live longer and spend longer in retirement, the cost of retirement will necessarily continue to rise. This means that retirees will receive a lower income in retirement from their lifetime's pension savings. In order to counterbalance the unpleasant effects of increased retirement cost, an obvious remedy is to delay retirement, thus re-adjusting the balance between working and retirement years.

With the increasing prominence of DC pensions in the United States, much work has been carried out on constructing optimal DC plans. Following the seminal papers of Samuelson and Merton in 1969 on optimal life-time consumption and investment strategies, much work has been done on life cycle finance.^{1,2} Also, in the financial services industry, life cycle investing is now a largely undisputed element of investment planning for retirement. At the same time, this has not prevented improvements being suggested in order to add realism to the basic theoretical construct Bodie *et al.*^{3,4}

One aspect of life-cycle strategies seems, however, to have been given comparatively little attention: the retirement age (RA). As longevity increases, increasing the RA would seem to provide a logical counterbalance, providing a useful instrument to rebalance lifetime, consumption, saving and investing. In this article, we analyse the effectiveness of using the RA as a means to derisk DC pension plans, introducing the concept of an 'Equilibrium Retirement Age' (ERA) and showing how this increases as life expectancy rises.

In the first section, 'Longevity and retirement income', we discuss the impact of increasing longevity on pension systems. In the second section, 'Retirement adequacy', we show how an individual can achieve equilibrium between capital accumulated in working life and capital required in retirement. In the third section, 'The ERA', we derive a closed-form formula for a simplified version of the equilibrium challenge and show how this can be used to gain some

insight into the trade-offs a DC plan participant faces. In the fourth and final section, 'DC planning in uncertainty', we put this in a wider context by discussing the options available to the DC plan participant to manage retirement planning risks, including longevity risk.

LONGEVITY AND RETIREMENT INCOME

It has long been recognised that increasing longevity poses a threat to worldwide pension systems. As early as 1976, Peter Drucker already saw that pension funds were under pressure from increasing longevity.⁵ Many have since described this risk from various perspectives (see, for example, Ambachtsheer⁶).

Ageing has been identified by many, both in academia and in public policy, as a threat to social security systems worldwide. Clearly, the combination of decreasing fertility and increasing longevity has a significant impact on old age dependency ratios and hence the sustainability of social security systems, which are often operated through 'pay-as-you-go' mechanisms.

Increasing longevity is also recognised as a threat to second pillar occupational pensions. For example, Antolin has constructed a stochastic mortality model and described the impact that longevity risk has on DB plans (Antolin⁷; Cox *et al.*⁸). Here, instead we will focus on the impact that increasing longevity has on DC plans. In particular, we see how RA can be used by individuals as an instrument to 'balance the books'.

According to projections based on an orderly and internally consistent stochastic model calibrated to Dutch history, the life expectancy of a Dutch male at 65 will increase from 20.1 to 25.7 in 40 years, assuming reasonable future mortality improvements (see further Madsen, C. and Tans, M., 2011, for a more detailed analysis of life expectancy projections in the Netherlands, United States and United Kingdom).⁹ It could rise as high as 32 years in the same timeframe. Bad habits that came with increased prosperity kept life expectancy at fairly stable levels between 1950 and 1970, though it continued to rise.

Figure 1: Life expectancy including improvements at age 65 in Spain – fairly similar to trends and indications in the Netherlands, United Kingdom, United States and other countries we have studied underscoring that this is a broad cross-border development.

As medicine improved and people became more conscious of health issues in the 1990s, life expectancy increased further (Figure 1).

The impact of increased longevity is significant. People aged 65 in 2050 or later may expect to live to more than 90, while the generation before them, who turned 65 in 2010 or earlier, may expect to live to less than 85. As life expectancy increases, income from retirement savings will have to be paid out over more years, which means that retirees will receive less money per year for the same amount of capital. Whether the retiree purchases an annuity or draws down accumulated wealth, increasing longevity will increase the cost of retirement, assuming the age of retirement remains the same.

The cost of retirement depends upon two main factors: interest rates and mortality assumptions. Table 1 shows the differing levels of income streams that can be acquired with a capital sum of €100 000 as life expectancy increases over time assuming a flat interest rate of 5 per cent (Figure 2).

As life expectancy rises, retirement income drops substantially – an individual retiring in 2050 would receive almost 37 per cent less

Table 1: Life expectancy and cost of retirement, based on a stochastic model calibrated for Dutch statistics

Year of Birth	Year turning 65	Life expectancy @65	Cost of retirement. Price for €1 annually, until death	Income stream for €100K
1915	1980	13.4	8.9	€11 291
1945	2010	19.4	11.5	€8 714
1975	2040	24.7	13.5	€7 381
2005	2070	27.6	14.5	€6 906

Figure 2: Life expectancy at age 65 versus cost of retirement.

annual retirement income than an individual in 1970 – and this takes no account of the effects of inflation. If we factor in the consequences of inflation, the impact on the individual would be even more serious, as inflation has longer to take effect: the extra years of life at the end count for more.

RETIREMENT ADEQUACY – A BALANCING ACT

In order to take a closer look at retirement adequacy, we begin by designing a deterministic framework for retirement planning in a DC context. This enables us to demonstrate the effectiveness of changing RA as a response to increasing life expectancy.

Bloom, Canning and Graham created a framework in which life expectancy is known to the individual with certainty and interest rates and wage growth are 0. In this framework, they show that the optimal response to an increase in life expectancy is to have the period of working life increase proportionally Bloom *et al.*¹⁰ In a later paper, Bloom, Canning and Moore developed a life expectancy model under

uncertainty. Increasing life expectancy allows individuals to reduce savings rates, balancing the book by having the RA increase more than proportionally Bloom *et al.*¹¹

Here, we assume contribution rates to be constant and independent of life expectancy. We do so as we aim to show how setting the RA can be used to mitigate the impact of increasing life span, all things being equal. Although longevity risk has been a focus of attention in academic papers, the financial world still appears to be underestimating the impact of longevity risk on individuals and has yet fully to recognise the role that a flexible RA may play in mitigating this risk. If we look at practical examples of life cycle finance, in most situations, life cycle strategies start by fixing a target RA, as opposed to using a flexible RA as one of methods available to establish an optimal (and realistic) programme of savings, consumption and investment strategies.

Foreman and Chen¹² argued that by defining a standard RA, we are effectively defining RA as a number of 'years-since-birth', while RA could better be viewed as determining the remaining 'years in retirement' or the ratio between working years and retirement years. Building on this suggestion, we propose here the use of the 'ERA'. ERA is the RA that balances savings in working life with payouts in retirement. The ERA helps to provide guidance on how individuals should respond to life expectancy changes, and has a useful role to play in product design, communication and public policy.

The concept underlying the ERA is straightforward: we need to find the RA such that account value (V) at retirement is equal to the value of the annuity (A) that generates the required income stream¹³.

$$V(RA) = A(RA) \quad (1)$$

In a simple discrete time model the account value V is determined by

$$V(RA) = \sum_{i=BA}^{RA} C \times Sal_{BA} \times (1+g)^{i-BA} \times (1+s)^{(RA-i)} \quad (2)$$

Figure 3: The later the year of birth, the later the ERA. Here, we show that someone turning 65 in 1975 could indeed retire at age 65, but – all things other than longevity remaining equal – the equivalent RA based on a year of birth in 2005 would be 71.

Contributions are made at a constant contribution rate C of a salary Sal that increases with a constant growth rate g . The account generates a constant investment return s .

The annuity price $A(RA)$ is determined by

$$A(RA) = R \times Sal_{RA} \times \sum_{i=RA}^{LE} (1+r)^{-(i-RA)} \quad (3)$$

$A(RA)$ is the capital required at retirement to be able to receive a constant annual income stream to the amount of the replacement rate R times the salary at retirement Sal_{RA} . R is the discount factor (Figure 3).

Postponing retirement by a year has a dual impact: it both decreases the annuity price and also lengthens the period in which DC assets can be saved and accumulated. Delaying retirement is a very effective mechanism.

In the current environment and in the future, with lower mortality rates and more expensive annuities, delaying retirement may become necessary simply in order to attain the required level of retirement income. The good news is that delaying retirement is a powerful way to balance pre-retirement savings with in-retirement needs.

THE ERA

Clearly, there is a direct relationship between life expectancy and RA. All other things being

equal, adding 1 year to life expectancy should push the ERA upwards by somewhere between 1 and 6 months. This statement alone may not seem intuitive. How is it that 1 more year of life expectancy only increases the ERA by less than half a year? In this section, we explore that relationship a little more closely by deriving a simplified, closed form description of ERA.

(2) can be rewritten as follows

$$V(RA) = \frac{C \cdot Sal_{BA}}{s - g} \times \left[1 - \left(\frac{1+g}{1+s} \right)^{RA-BA} \right] \quad (4)$$

and

$$V(RA) = C \times sal_{BA} \times \frac{(1+s)^{RA-BA} - (1+s)^{(RA-BA)}}{s - g} \quad (5)$$

(3) can be rewritten as

$$A(RA) = Sal_{BA} \times (1+g)^{RA-BA} \times R \times \left(\frac{1}{r} - \frac{1}{r \times (1+r)^{LE-RA}} \right) \quad (6)$$

To derive the ERA we need to solve (1), (5) and (6) for the RA. This can be done if we introduce two additional simplifications: the growth rate g of salary = 0 and that the investment return s is equal to the discount rate r . $s = r$.

Under these simplifications, (1), (5) and (6) reduce to

$$(1+r)^{RA-BA} \times (1+r)^{LE-RA} - (1+r)^{LE-RA} = k \times (1+r)^{LE-RA} - k \quad (7)$$

where $k = R/C$, the ratio between the replacement rate and the contribution rate.

Solving (7) for RA, we get a closed form description of the 'ERA'

$$ERA = LE + \frac{\ln(1+k)}{\ln(1+r)} - \frac{\ln((1+r)^{LE-BA} + k)}{\ln(1+r)}$$

Given that we have written the RA as a function of life expectancy, beginning age, contributions and interest rates, we can now begin to look at key sensitivities. For example, if we want to look at the sensitivity of ERA to LE, we get the following:

$$\frac{\partial ERA}{\partial LE} = 1 - \frac{(1+r)^{LE-BA}}{(1+r)^{LE-BA} + k}$$

Given these, Table 2 can be produced to illustrate some of the sensitivities

There are several interesting observations that can be drawn from Table 2. First, when rates are in a 'normal' range of 3–5 per cent, the sensitivity of the ERA to LE is generally in the range of 0.4–0.5. In other words, each time life expectancy rises by 1 year, we should expect RA to increase by a little less than half. In a low interest rate environment, the sensitivity will increase. When rates are low, the increase in Life Expectancy has to be fully compensated by the delay in Retirement.¹⁴ At the moment, annual improvements in life expectancy are approximately 3 months. Thus, we would expect the RA to increase by 1 to 2 months per year.

The ERA is clearly very sensitive to interest rates. For a 1 per cent absolute decrease in interest rates, the ERA increases by almost 4 years. Viewed over long time horizons, we would expect a medium-level interest rate of 3–5 per cent, but this ignores the point in time

Table 2: Table illustrating the ERA for various scenarios using assumptions stated

Replacement ratio (%)	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	60.0	50.0	47.5
Contribution rate (%)	8.0	8.0	8.0	10.0	11.0	11.0	11.0	15.0	20.0	25.0	25.0	25.0	25.0
k	8.75	8.75	8.75	7.00	6.36	6.36	6.36	4.67	3.50	2.80	2.40	2.00	1.90
r (%)	5.0	5.0	5.0	5.0	5.0	3.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
LE	80.0	85.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
BA	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
ERA	65.1	67.1	68.8	66.1	64.9	72.8	79.4	76.5	73.2	70.4	68.4	65.8	65.1
dERA/dLE	0.43	0.37	0.32	0.27	0.25	0.52	0.78	0.72	0.66	0.61	0.57	0.52	0.51

Figure 4: The ERA is very sensitive to the interest rate. For a Replacement Rate of 70 per cent and a contribution rate of 10 per cent the ERA is 66 for when interest rates are 5 per cent, while the ERA is 82.5 year as interest rates approach 0 per cent. Likewise, the dERA/dLE, is also very sensitive to interest rates. In a low rates environment every year of additional LE requires the RA to increase by 9, 10 or 11 months.

risk that a retiree faces if purchasing an annuity at the time of retirement. Ironically, the point-in-time risk is reduced if retirees manage their own funds, which actually introduces other risks (Figure 4).

DC PLANNING IN UNCERTAINTY

In the light of current demographic and economic data, the middle-aged and younger generations of today may well be forced to postpone their retirement significantly in order to balance their books.

In order to see how ERA can help today's workers to save and plan for retirement, we can take the example of an imaginary participant accumulating contributions over time and then purchasing an annuity at retirement at actuarially equivalent prices.

Let us take a male participant in the Netherlands, born in 1965 and who started to contribute at the age of 30. With a contribution rate of 9.7 per cent, an investment return of 7 per cent and an annuity discount rate of 5 per cent, the participant would reach his target replacement ratio of 70 per cent at the age of 65.

However, the past decade has not been easy on financial planning. The triple whammy of lower investment returns, lower interest rates and improved longevity has pushed the replacement ratio down to 30 per cent.

In order to restore his retirement savings to an appropriate level for retirement (still assuming this is a 70 per cent replacement ratio), the participant would have to delay his retirement by a little more than 9 years (Figure 5).

Delaying retirement is in many ways an obvious measure to take when faced with longer life expectancy. In 1980, an individual turning 65 having contributed at an 8 per cent contribution rate from the age of 30 and having achieved a 5 per cent investment return, would have had the funds needed to purchase a 70 per cent replacement rate annuity. However, as life expectancy has increased, this has changed. Today, an individual with the same characteristics needs to retire 6 years later in order to have the same results. While this fact may seem iniquitous to some, it largely reflects the stability of the balance required between working life and retirement.

It is clear that increasing life expectancy will have a considerable impact on DC pensions, and that this is not a problem that will be solved quickly or easily. In addition to the tools already available, a variable RA may help to fill the savings shortfall, shifting the balance between the accumulation and distribution phases. Delaying retirement may increasingly be used as a counterweight to increasing longevity. Some countries have already begun to adopt such an

Figure 5: Even if an individual planned for retirement income in the past, increased longevity, lower investment returns and lower interest rates take their toll. One option is to retire later, if the objective is still to replenish the same proportion of at-retirement income throughout retirement. Another option is to retire at the same time, but accept a much lower income replacement ratio.

approach, even if this is not always explicitly defined.

Until now, the models used in this article have assumed that future life expectancy is essentially a known parameter. In fact, this is not the case. We do not know what future life expectancy will be – and this has important implications for financial planning.

When individuals start saving for retirement, perhaps at the age of 25, they do not yet know what their average life expectancy is going to be, nor what the price of an annuity will be when they reach their RA. It is therefore useful to introduce the use of a probability-based or stochastic model to help illuminate the levels of uncertainty and the possible outcomes.

If we extend our example of the person who retires at age 67 instead of age 65, we can look at what would happen to that person's planning if the 99.5th percentile came true. We have already observed that, by retiring 2 years' later, the replacement ratio moves from 66.5 to 76.0 per cent. In a 99.5th type longevity event occurring today, that person's replacement ratio would drop back to 65.9 per cent. In this simple example, an individual may wish to plan to retire a couple of years later in order to be reasonably certain that retirement replacement income will be sufficient under all longevity scenarios.

This uncertainty about longevity indicates that the design of DC plans and life cycle strategies should be expanded along three lines:

- DC planning should explicitly allow the monitoring and management of an additional risk factor, longevity risk. DC investment strategies typically incorporate some forms of interest rate risk, equity risk, and sometimes inflation risk as well. It is now time to include the factor that is often still overlooked: longevity risk. In addition, the other risk factors may also affect annuity pricing. This also needs to be explicitly considered.
- DC investors have another instrument at hand that they can use in their financial planning: delaying retirement. How effective or desirable this is depends upon personal circumstances and choice. One individual may well be happy to run the risk of having to work another few years, while the other needs to be sure that at 65, they can retire. The use of the ERA and stochastic modelling can help individuals both to see the consequences of their actions and to make the choice that suits them best.
- There is an additional instrument available that could conceivably also be used to manage longevity risk in DC plans. The market is starting to see the development of investment vehicles that track longevity risk. In a way,

the risk-free asset in DC is not cash or even long bonds, but rather deferred annuities, and DC plans would be more effective if such 'investments' were to be made available to savers. Though not traditionally thought of as an investment, a deferred annuity generates an excellent return when longevity increases or interest rates decrease. A similar type product could be a longevity bond (EIB, 2004) where coupons increase as longevity increases. For many investors looking for fixed income and to protect longevity, this would be a very desirable product.

CONCLUSIONS

DC plans shift risk and responsibility to the individual, and studies show that individuals require assistance (see, for example, Smith Brothers¹⁵). This has been the case with assets and it will also be the case with the assessment of liabilities.

For DB funds, longevity has moved relatively recently onto the radar. The impact of longevity and its impact on individuals with DC plans, however, has received relatively little attention. Longevity is likely to have a significant impact on individuals, who are in any case typically not saving enough. Everyone has a role to play in helping to deal with the consequences of this.

The concept of the ERA may help in two ways:

- In an ageing society, there is likely to be more demand for older workers. This needs to be stimulated and the ERA may help individuals to plan for longer working lives together with their employers.
- In addition, the ERA may provide a powerful stimulus for those individuals who are capable of doing so to save more in order to be able to retire sooner.

Managing pensions is about risk management and good planning – both for DB sponsors and for individuals. By including the ERA in pension

planning for DC participants, the concept of balancing savings with post-retirement needs can be used to help individuals plan for a well-funded and timely retirement.

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