DISCUSSION PAPER PI-0806

Turning Pension Plans into Pension Planes: What Investment Strategy Designers of Defined Contribution Pension Plans can Learn from Commercial Aircraft Designers

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April 2008

ISSN 1367-580X

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Turning pension plans into pension planes: What investment strategy designers of defined contribution pension plans can learn from commercial aircraft designers

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Prepared for the World Bank's 'Pension Competition and Asset Allocation Policies for Mandatory DC Funds' Research Project (P102187). The authors are grateful for the constructive comments on an earlier draft received from Arjan Berkelaar, Greg Brunner, Steijn Claessens, Gregorio Impavido, Jeppe Ladekarl, Heinz Rudolph, Sergio Schmukler, and Euardo Levy Yeyati. Presented at the World Bank's 'Fourth Contractual Savings Conference: Supervisory and Regulatory Issues in Private Pensions and Life Insurance', Washington DC, 2-4 April 2008

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Abstract

Many, if not most, individuals cannot be regarded as 'intelligent consumers' when it comes to understanding and assessing different investment strategies for their defined contribution pension plans. This gives very little incentive to plan providers to improve the design of their pension plans. As a consequence, pension plans and their investment strategies are still currently in a very primitive stage of their development. In particular, there is very little integration between the accumulation and decumulation stages. It is possible to produce well-designed DC plans but these need to be designed from back to front (that is, from desired outputs to required inputs) with the goal of delivering an adequate targeted pension with a high degree of probability. We use the analogy of designing a commercial aircraft to explain how this might be done. We also investigate the possible role of regulators in acting as surrogate 'intelligent consumers' on behalf of plan members.

Key messages of this report

1. Currently, the design of DC plans is inadequate for a number of reasons:
   - members are required to make very complex investment choices without having the skills to do so
   - during the accumulation stage, fund managers invest contributions taking into account the member's risk aversion, but without taking into account the decumulation stage and, in particular, the standard of living desired in the decumulation stage; in other words, fund managers have no target fund to accumulate.
2. Hence, there is a need to design to design plans recursively from back to front, i.e., from desired outputs to required inputs (this design strategy is known as dynamic programming). In a sense, we can think of a well-designed DC plan as being like a defined benefit plan, offering a promised retirement pension, but without the guarantee implicit in the DB promise. In other words, a well-designed DC plan will try to target a particular pension by generating the lump sum on the retirement date needed to deliver that pension in the form of a life annuity, although it will not be able to guarantee to deliver that target pension. This is because guarantees over long investment horizons are very expensive to secure.
3. The academic literature tells us that when investment opportunities are time varying, fund managers should try to time the market. For example, when the equity premium is expected to rise, the fund manager should buy more equities, and when interest rates are expected to fall, the fund manager should buy more bonds. However, the empirical evidence shows that market timing cannot be implemented in practice with any degree of success. Hence, there is a need to tie the hands of fund managers.
4. The way to tie the hands of fund managers is not through quantitative investment rules but through target annuitisation funds that managers need to replicate.
5. These should be designed using some form of lifestyling investment strategy during the accumulation stage with a high initial weight in equities with a switch to bonds as the retirement date approaches; in practice, the strategy is likely to be deterministic due to the information intensive nature of stochastic investment strategies, such as stochastic lifestyling. Lifestyling is justified by two properties of equity returns for which there appears to be strong empirical evidence, namely mean reversion in equity returns and a positive equity premium. These two properties suggest that equities should play a large role in the portfolios of young pension plan members. Lifestyling is also justified by recognising that human capital is an important bond-like asset of the plan member which decays over the member's working like. As the time of annuitization approaches, bonds should play a greater role in order to hedge the interest rate risk in the annuity purchase and to compensate for the decay of human capital.
6. The purpose of lifestyling is to reduce the risk of falling short of the target and to reduce the variability of contributions into the plan during the accumulation stage. Given the nature of the target that the investment strategy is intended to achieve, members should be given only limited choice over which lifestyle fund to invest in.

7. The annuitisation and retirement ages do not need to be the same. This is especially so for richer individuals who can afford to have some flexibility over both when they retire and when they begin to draw their pension.
8. The menu of retirement products can include flexible annuity vehicles that take into account the member's degree of risk aversion and the bequest motive of retirees. Individuals with a low degree of risk aversion might wish to consider an investment-linked retirement income programme, such as an investment-linked annuity.
9. For poorer individuals, such choice flexibility is unlikely to be feasible. In fact, to avoid the potential moral hazard problem of individuals consuming their retirement pot too quickly and falling back on the state for support, there needs to be a minimal annuitisation fund accumulated before any investment flexibility post-retirement should be permitted. Members with accumulated funds below the minimum annuitisation fund level needed to keep them off further state support should be required to purchase an index-linked life annuity with their accumulated fund.
10. A key role of the regulator or other parties responsible for pension funds might be to design pension plans to minimise behavioural biases including:
    - having target annuitisation funds as default options during the accumulation stage
    - allowing flexible retirement products that take into account risk aversion and bequest motives (especially in countries with large first pillars)
    - better information to members concerning the various tradeoffs implicit in a DC pension plan
    - helping to complete the market for longevity insurance.
11. This analysis needs to be modified for developing countries, since equity markets are more volatile and less liquid than in developed countries, because there are fewer investment alternatives than in developed countries, because markets are less complete (e.g., annuity markets), and because there are other risks that are not as severe in developed countries (e.g., currency and confiscation risks). These factors will tend to weaken the efficaciousness of DC plans in developing countries, unless measures are taken to rectify them.

What we call the beginning is often the end
And to make and end is to make a beginning
The end is where we start from.
T S Eliot, Little Gidding, No. 4 of the Four Quartets, 1942

1. Introduction

A man walks into a Washington DC travel agent and has this conversation with the sales agent:

Agent: How can I help you Sir?
Man: I would like to book a flight from Washington to Santiago
Agent: Before I check flight availability, I need to ask you a few questions. Can you please tell me about your attitude to risk.
Man (looking a little puzzled): My attitude to risk? What do you mean, my attitude to risk?
Agent: Yes Sir, have you fully factored into your decision about how you get to Santiago all the possible risks involved?
Man (showing signs of impatience): I'm in bit of a hurry and would just like to buy a ticket now if that's okay with you.
Agent: Sir, do you know the probability of in-flight loss of control due to extreme turbulence?
Man (his eyes opening a little more): Well no, actually.
Agent: Sir, you will know how risky landing is, but are you aware of how many accidents are caused while an aircraft is taxiing, loading or parking?
Man (face starting to redden): No, I am not!
Agent: Sir, did you know that you are twice as likely to die in an aircraft as a result of icing than as a result of a midair collision?
Man (having had enough and turning to leave): No I didn't, I think I'll walk to Santiago instead!
Agent (as the man storms out of the shop): Sir, are you aware how risky walking is? Have a nice day.

Now conversations of this kind do not take place that often, of course. The reason for this is that commercial airline flights involve very little risk. According to Boeing Commercial Airlines (2006), the accident rate on scheduled passenger airlines was 0.89 per million departures. This looks safe and, relative to other modes of transport, it is very safe (see Table 1). For a British citizen, for example, flying is 30 times safer than driving a car, about 550 times safer than walking, and nearly 800 times safer than a motorcycle. Indeed, it is possible to argue that air travel is by far the safest way to die! And the reason it is so safe is that aircraft designers had to overcome people's fear of flying: it does not take long for an airline passenger to know whether they are using a safe means of travel or not.

Aircraft designers also needed to find out very quickly when and how accidents happen. In this regard, it is interesting to look at Table 2 which shows the distribution of accidents and fatalities by phase of flight. The table shows that most (46%) accidents happen during landing, but 8% happen during taxiing, loading or parking. Table 3 shows that the flight crew and the aircraft itself are the primary cause of most accidents, but 13% of accidents are caused by weather conditions, including extreme turbulence. Table 4 shows that most fatalities are caused by controlled flight into terrain (including water) or by in-flight loss of control; it also shows that there are twice as many fatalities caused by icing than are caused by mid-air collisions.

Table 1 Passenger deaths by mode of transport (Rate per billion passenger kilometres, Great Britain)	
	Average 1981 - 2003
Motorcycle	95.83
Walking	66.07
Pedal cycle	44.60
Car	3.76
Van	2.03
Water	1.95
Rail	0.66
Bus or coach	0.37
Air	0.12
Sources: Table 12.21, *Social Trends 30* (2000) and *Social Trends 36* (2006)	

Table 2 Distribution of accidents and fatalities by stage of flight, 1996-2005			
	Percentages		
	Accidents[a]	Fatalities[b]	Exposures[c]
Taxi, load, parked	8	1	-
Takeoff	12	11	1
Initial climb	5	16	1
Climb (flaps up)	8	26	14
Cruise	6	14	57
Descent	2	3	11
Initial approach	7	14	12
Final approach	6	13	3
Landing	46	2	1
Notes: a) Hull loss and/or fatal accidents, b) Onboard fatalities, c) Percentage of flight time (based on flight duration of 1.5 hours)			
Source: Boeing Commercial Airlines (2006, p 16)			

Table 3 Distribution of accidents by primary cause, 1996-2005	
	Percentages
Flight crew	55
Airplane	17
Weather	13
Airport/air traffic control	5
Maintenance	3
Other (including running out of fuel)	7
Source: Boeing Commercial Airlines (2006, p 17)	

Table 4 Distribution of fatalities by category, 1987-2005	
	Percentages
Controlled flight into terrain (including water)	36
Loss of control – in flight	28
System/component failure (non-power plant)	8
Fire/smoke (non-impact)	6
System/component failure (power plant)	5
Undershoot/overshoot	3
Fuel related	2
Runway excursion	2
Icing	2
Midair collision	1
Abnormal runway contact	1
Runway incursion	1
Other/ unknown	5
Source: Boeing Commercial Airlines (2006, p 18)	

Why are pension plans not designed in the same way as commercial aircraft? At first sight, you might think that this is a strange question. It is, however, also a very instructive one. In fact, there are many similarities between pension plans and aircraft, and designers of pension plans have much to learn from aircraft designers. The purpose of this paper is to spell out these lessons by using the framework of designing a commercial aircraft to illustrate how the investment strategy of a personal defined contribution (DC) pension plan should be designed if it is to achieve its objective of delivering an adequate and secure pension in retirement for the pension plan member. As in the design of a commercial aircraft, there are trade-offs to be made, but these tradeoffs are much fewer and more clearly defined than you might have realised. More importantly, understanding the process of designing an aircraft will greatly improve your understanding of what an optimal DC pension plan might look like. It can also considerably simplify the task of those such as pension regulators whose task it is to oversee personal DC pension plans.

This paper is organised as follows. Section 2 identifies the lessons that a DC plan designer can learn from the aviation industry. Section 3 looks at how the investment strategies of DC pension plans are currently designed. Section 4 draws a comparison between pension plans and commercial airline journeys, while section 5 shows how the lessons learned in section 2 can be applied to the design of DC plans. Section 6 investigates the role of regulators, while section 6 examines whether there is a role for government in helping to hedge the longevity risk that pension funds face, and which cannot currently be hedged with existing instruments. We draw conclusions in section 6.

2. Please fasten your seatbelts: Lessons from the aviation industry

All journeys begin at the end. When you plan a journey you know where you want to end up. The airline flying you there also needs to know this, because it needs to use an aircraft capable of reaching the required destination and it needs to ensure that the aircraft has enough fuel. It also needs to know when you wish to reach your destination. The airline gives you some other choices that you might consider important such as the class of seat and the type of food. But these choices, although important to you, are not really important for the airline, whose paramount concern is to get you to your destination safely. And the key word here is 'safely'. The most important service an airline provides is landing safely. This dominates everything else. No amount of good food and no seat however comfortable are going to compensate you for a crash landing. Risk is therefore the critical issue in the design of any commercial aircraft.

When you fly over Washington into Reagan National Airport on a clear, sunny day, it looks like a model village. You can imagine reaching your hand out of the window to pick up the White House or the Capitol Building. But you are still a long way off the ground if anything should go wrong. Fortunately, it is very rare for things to go wrong. An airline journey is, as we have just seen, very safe.

But it wasn't always the case. In the beginning, commercial flight was very risky and there was a lot of experimentation with new designs. Aircraft designers understood that the problem of safety needed to be sorted out very quickly. Passengers demanded safety and very soon both aircraft manufacturers and airline companies put safety as their top priority.

This led to something quite remarkable: aircraft manufacturers soon started building very similar aircraft with almost identical safety standards. Sitting inside a modern commercial aircraft, can you really tell whether it is a Boeing or an Airbus? If you closed your eyes when you listened to the safety announcement at the start of your journey, can you really tell whether the aircraft was being operated by Emirates or Qantas? The key safety message is always the same: 'please fasten your seatbelts'. That's about the only safety precaution the passenger needs to make.

This should come as no surprise. When it comes to the tradeoffs between aerodynamic efficiency, safety and commercial viability, there are only so many ways to design an aircraft. Indeed, aircraft designers have become so successful in resolving these tradeoffs that most passengers give safety barely a moment's thought. So much so, in fact, that it is not uncommon for passengers to become impatient when their journey is slowed down to deal with safety issues.

Yet it took a great deal of effort to get to this point. Building a commercially successful aircraft requires advanced production processes, substantial research and development and a highly trained and integrated workforce, comprising aerospace engineers, aircraft mechanics and service technicians, computer engineers and scientists, computer systems analysts, electrical and electronics engineers, engineering technicians, machinists and numerical tool and process control programmers, mechanical engineers, metalworking and plastics-working machine operators, precision assemblers, tool and die makers, welders, cutters and welding machine operators.[1]

Having designed and built an aircraft, the aircraft manufacturer needs to persuade commercial airline companies to buy it. Any new aircraft chosen by a commercial airline will need to satisfy a number of criteria that depend on the routes and market that the airline operates in, such as size, range, seating arrangements and cargo capacity. The aircraft chosen by the airline will ultimately depend on the

[1] Source: https://guide.symplicity.com/resources/industry_article.php?id=13#sources: Aerospace manufacturing.

manufacturer's ability to deliver a safe and reliable aircraft that best fits their market requirements at the lowest cost and on the most favourable financing terms.

The traditional design methodology concentrated on technical design and involved minimising gross takeoff weight (GTOW), the objective being to lower operating costs through reduced fuel consumption. It is also important to design aircraft that are financially viable, and this requires a multi-disciplinary design optimisation (MDO) approach that not only examines performance, but also incorporates financial modelling such as life cycle cost, direct operating cost and product-demand analyses. A key component of MDO is the evaluation of design risk, that is, how technical and financial uncertainty influence performance and value. It also makes use of stochastic dynamic programming (DP) to aid decision making at each stage in the design process.

The overall programme involves a tradeoff between aerodynamic efficiency and fuel efficiency (and thus aircraft price), on the one hand, and lower GTOW (and thus operating cost) on the other. Peoples and Willcox (2006) illustrate this tradeoff by considering the effect of reducing the chord (the width of an aircraft's wing) at the wing tip relative to the baseline design (that minimises GTOW) by 23%. They report that this reduction helped to reduce manufacturing costs but also increased fuel consumption. Although structural weight fell, fuel weight increased, but there was still a net reduction in GTOW and expected net present value (ENPV) increased by 2.3%. However, these findings assume a fixed price for fuel. If fuel prices increase by 25%, for example, the change in the ENPV resulting from the redesigned wing tip becomes negative. All this highlights the importance of taking market assumptions into account in aircraft design.

Peoples and Willcox (2006, p 921) highlight the benefits of MDO:

- It 'allows more informed program decisions regarding design specifications, as evidenced by the findings that longer ranges and higher speeds offer diminishing returns in value'.
- It produces sensitivity analyses that 'indicate that the effects of fuel cost, recurring cost, and aircraft price on the long-term profitability of the design pose the greatest risk.' It also demonstrates that market uncertainty is a source of considerable risk.
- It shows that it is financially safer to incur costs early in a project to ensure a successful design than it is to go to market prematurely with a design that has missed performance goals.

The ultimate objective is to find the optimal design for which 'increased demand uncertainty is such that the confluence of beneficial events could result in a highly successful program, and the probability of a market decline is not high enough to drastically lower the expected value' (Peoples and Willcox (2006, p 920)).

But we should not lose sight of the fact that the only reason why so much effort goes into the design of commercial aircraft is the *immediate* and very public reputational damage to both the designer and airline operator from a catastrophic design failure. Airline passengers might not know much about the technical issues of aircraft design, but they can certainly identify a catastrophic design failure when they see one. In this sense, they can be classified as 'intelligent consumers': they demand safety and they get it.

We now turn to investigate the current 'design' of DC pension plans.

3. How are DC pension plan investment strategies currently designed?

This section looks at how DC pension plans are currently designed in terms of structuring a portfolio of accumulating assets in the light of the plan member's degree of risk aversion. The standard procedure is to adopt a single-period investment strategy which depends on the equity premium and the risk penalty (the product of risk aversion and the risk level assumed) and this results in a demand to hold equities and cash in the portfolio. Pension funds invest over many periods, however, and a multi-period investment strategy needs to take account of time-varying investment opportunities, especially long-term mean reversion on asset returns. It is optimal for pension funds to become strategic market timers and to respond to forecast changes in investment opportunities, especially changes in the structure of interest rates. The desire to hedge interest rate risk creates an intertemporal hedging demand for a new class of asset, namely bonds. The problem is that, in practice, pension fund managers have shown themselves to be very poor at getting their market timing decisions right.

We can think of DC plans as having three stages – the initial marketing stage, the accumulation stage and the decumulation stage – and it is curious to note that there is currently very little connection between them. This is, in part, because the three stages are arranged by three different and disconnected groups of people: the sales agent of a pension plan provider who competes against other providers, the fund manager appointed by the chosen provider, and the annuity seller who often works for a life office that is not part of the same group as either the plan provider or the fund manager. The lack of connection between the three stages is also, in part, due to the fact that the customer, the potential pension plan member, generally has a very poor understanding of each stage and of the resources required and risks involved in delivering an adequate and reliable pension in retirement.

The fact that pension plan providers are not dealing with 'intelligent consumers' gives them very little incentive to give much thought to pension plan design, let alone take an integrated approach to it. What typically happens when a sales agent first meets a potential young customer is that it soon becomes apparent that the potential customer has both little interest in starting a plan and little spare money to do so. To induce the potential customer to sign up, the sales agent will suggest starting the plan on the minimum level of contributions that the plan provider will accept or that regulation allows. In the case of UK stakeholder pension plans (regulated personal DC plans with capped charges), this would be as little as £20 ($40) per month. For a young person with credit card debts and a mortgage, this might still seem like a lot of money, but it is wholly inadequate to build up a decent pension entitlement. But this will be of no concern to the fund manager who in a DC framework has no target retirement lump sum to reach. When the plan member finally retires, the annuity provider will take whatever lump sum the fund manager delivers and offer an annuity based on current interest rates and mortality prospects, with no concern about the standard of living this might provide to the plan member. When the plan member eventually discovers how low his pension really is, it is by then too late to do anything about it.[2]

In terms of investment strategy, the one concern that the fund manager has about the customer or plan member is to invest the contributions in a portfolio of assets in accordance with the plan member's attitude to risk.

3.1 The plan member's attitude to risk

The member's attitude to risk is conventionally measured by the *coefficient of relative risk aversion* (γ). This is defined as the wealth elasticity of the marginal utility of wealth (cf., Blake (2006, eqn (4.10)):

$$(1) \qquad \gamma = -\frac{WU''(W)}{U'(W)}$$

where the member's pension wealth is denoted by *W*, the utility of (or welfare derived from) pension wealth is denoted by $U(W)$, the marginal utility of pension wealth (i.e., the change in utility if pension wealth changes by \$1) is denoted by $U'(W)$, and the degree of curvature of the utility function of pension wealth (which measures the rate at which marginal utility changes if pension wealth changes by \$1) is denoted by $U''(W)$. For all investors, $U'(W) > 0$, utility is increasing in wealth: more wealth means higher utility. For risk averse investors, $U''(W) < 0$. This means that their utility functions are positive but concave functions of wealth, which implies that a \$1 increase in wealth increases utility by less in absolute terms than a \$1 reduction in wealth reduces utility. This can be seen in Fig. 1. The greater the curvature of the utility function (or the more negative is $U''(W)$), the greater the degree of risk aversion.

This, in turn, means that investors who are risk averse will tend to have lower holdings of risky assets than risk-seeking investors. Risky assets, such as equities, have higher returns in boom conditions than conservative assets, such as bonds, but lower returns in slump conditions. Risk-averse investors are prepared to forego some of the upside potential of equities if the investment conditions turn out to be favourable, in order to avoid some of the downside losses on equities if investment conditions turn out to be unfavourable. It is conventional to classify as highly risk averse (or conservative), those investors with a γ value above unity, and to classify as moderately risk averse those investors with a γ value between zero and unity. Risk-neutral investors have a γ value of zero and risk-seeking investors have a negative γ value.

[2] This report is primarily concerned with investment strategy during both the accumulation and decumulation stages and will therefore not examine the sales function further. In countries with mandatory participation in DC plans, the sales function is further circumscribed.

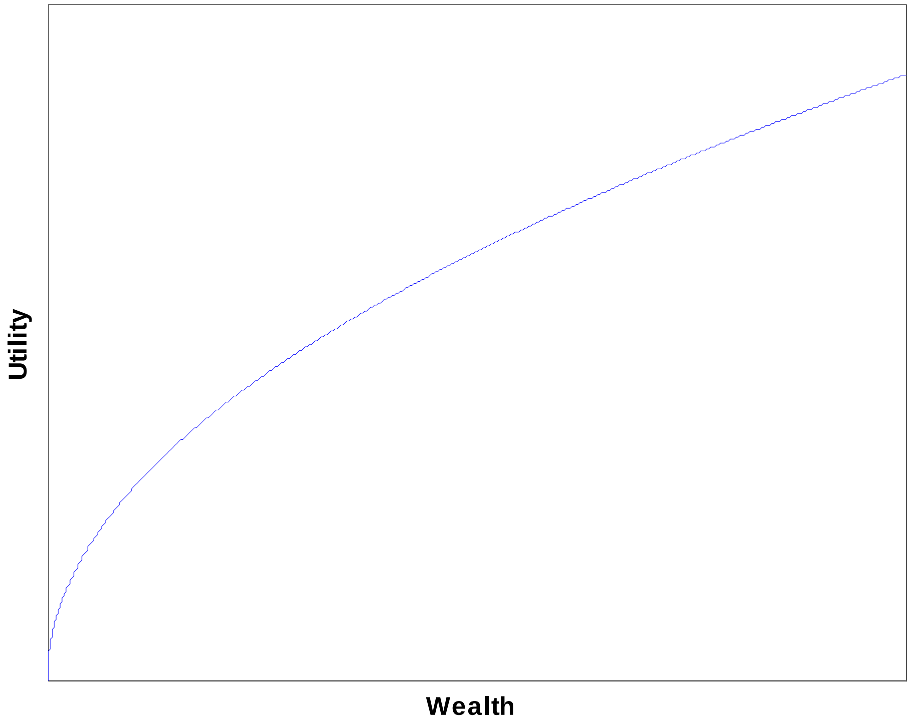

Fig. 1: Utility function exhibiting positive but decreasing marginal utility

The plan member's attitude to risk will also have potential implications for the volatility of contributions into the pension plan. The lower the degree of risk aversion, the higher the optimal equity weighting in the pension fund (as we will shortly demonstrate) and hence the more potentially volatile the value of the pension fund over time. If the plan member has a target pension fund value (or a target annuity amount) for the retirement date and the current value of the pension fund has fallen short of the level needed to reach that target, say as a result of poor equity returns, the only way to rectify this is to increase contributions into the plan if the retirement date is not to be delayed. Some members might not welcome volatile contributions into the plan, since it implies a volatile pattern to consumption over time. Such individuals are said to have a low intertemporal elasticity of substitution (IES) in consumption[3] (Blake (2006, p17)) and will prefer a lower equity weighting in their pension fund and hence more stable contributions over time and, as a consequence, a more stable consumption pattern. Just as there are usually a number of ways of getting from A to B, some bumpy but fast, others smooth but slow, so there are different ways of achieving a target retirement level pension fund. The plan member's degree of risk aversion will indicate to the fund manager which way will be preferred by the member in question: one with a high equity weighting and lower average but more volatile contributions, or one with a low equity weighting and higher average but more stable contributions.

[3] It is generally the case that individuals with a high degree of risk aversion also have a low IES and vice versa. In the case of individuals with a power utility function (as in section 3.2 below), the coefficient of relative risk aversion (γ) is the inverse of the IES (see, e.g., Blake (2006, pp. 94-95)).

3.2 Single-period investment strategy

The simplest asset allocation model in the academic literature is the myopic or single-period portfolio choice model (e.g., Campbell and Viceira (2002, chapter 2)). This assumes that the pension plan member has a power (or iso-elastic) utility function of wealth and that asset returns are lognormally distributed. The simplest power utility function has the property that the coefficient of relative risk aversion (γ) is constant both over time and for different wealth levels. We will allow for the fact that the individual has precautionary savings (which we assume are held in a risk-free asset, such as Treasury bills or a deposit account), but will assume that all long-term savings are held in the pension plan. To keep things simple, we will also assume to begin with that there are only two possible assets for the pension plan, a risk-free asset (which in line with standard financial market parlance we will refer to as 'cash') and a risky asset, equities.

If we are currently in period *t*, then the expected value of a one-period power utility function for the plan member at the end of period *t* (beginning of period *t*+1) is given by:

$$(2) \qquad E_t U\left(W_{t+1}\right) = E_t \frac{W_{t+1}^{1-\gamma}}{\left(1-\gamma\right)}$$

where E_t is the expectations operator based on information at the beginning of period *t*, and the budget constraint is:

$$(3) \qquad W_{t+1} = \left(1 + R_{p,t+1}\right) W_t$$

where W_t is real investable wealth at the beginning of period *t* and $R_{p,t+1}$ is the return on the portfolio of invested assets between the beginning of period *t* and the beginning of period *t*+1.

We assume that the gross return on the portfolio $\left(1 + R_{p,t+1}\right)$ is lognormally distributed.[4] This means that the natural log of the gross portfolio return $ln\left(1 + R_{p,t+1}\right) \equiv r_{p,t+1}$ – also known as the continuously compounded portfolio return – is normally distributed.[5] The natural log of the expected value of the gross portfolio return takes the value:

$$(4) \qquad ln\, E_t \left(1 + R_{p,t+1}\right) = E_t r_{p,t+1} + \frac{1}{2}\sigma_{pt}^2$$

where σ_{pt}^2 is the conditional variance of the log portfolio return (conditional on information up to time *t*).

[4] This assumption is valid only if the gross return on the risky asset is lognormal and if there is continuous rebalancing between cash and the risky asset in order to maintain constant weights.
[5] We adopt the convention of using a lower-case letter to represent the natural log of an upper-case letter.

The fund manager's objective is to choose the asset allocation that maximises expected utility (2) subject to the budget constraint (3). This is equivalent to maximising the natural log of (2):[6]

(5) $$ln\,E_t \frac{W_{t+1}^{1-\gamma}}{(1-\gamma)} = -ln(1-\gamma) + (1-\gamma)E_t w_{t+1} + \frac{1}{2}(1-\gamma)^2 \sigma_{wt}^2$$

where w_{t+1} is the log of pension wealth and σ_{wt}^2 is the conditional variance of the log of pension wealth, subject to the natural log of the budget constraint:

(6) $$w_{t+1} = r_{p,t+1} + w_t$$

If we now substitute (6) into (5) and recognise that w_t is predetermined at time *t* and so will not affect the optimal asset allocation and, further, that the optimal asset allocation does not depend on the size of the constant term in (5) or the common factor $(1-\gamma)$ in the other two right-hand side terms, then the fund manager's objective becomes:

(7) $$max\left\{ E_t r_{p,t+1} + \frac{1}{2}(1-\gamma)\sigma_{pt}^2 \right\}$$

or equivalently

(8) $$max\left\{ ln\,E_t\left(1+R_{p,t+1}\right) - \frac{\gamma}{2}\sigma_{pt}^2 \right\}$$

Equation (8) tells us that the fund manager chooses the investment strategy to maximise the risk-adjusted expected return on the accumulating pension fund. This risk-adjusted expected return is equal to the natural log of the arithmetic mean portfolio return $\left(ln\,E_t\left(1+R_{p,t+1}\right)\right)$ minus 50% of a *risk penalty*, where the risk penalty equals the product of the fund risk (as measured by the conditional variance of the fund's assets $\left(\sigma_{pt}^2\right)$) and the coefficient of relative risk aversion of the plan member (γ).

[6]The right-hand side of Eqn (5) follows from taking the natural log of the last line of the equation below:

$$\begin{aligned} E_t U\left(W_{t+1}\right) &= E_t \frac{W_{t+1}^{1-\gamma}}{(1-\gamma)} \\ &\equiv \frac{1}{(1-\gamma)} E_t e^{(1-\gamma)w_{t+1}} \\ &\equiv \frac{1}{(1-\gamma)}\left[e^{(1-\gamma)E_t w_{t+1} + \frac{1}{2}(1-\gamma)^2\sigma_{wt}^2} \right] \end{aligned}$$

Campbell and Viceira (2002, eqn (2.21)) show that, in the case of two assets, the log excess return (i.e., logarithmic *risk premium*) on the optimal portfolio is approximately:

$$(9) \qquad r_{p,t+1} - r_{f,t+1} = \alpha_t \left(r_{t+1} - r_{f,t+1} \right) + \frac{1}{2} \alpha_t \left(1 - \alpha_t \right) \sigma_t^2$$

while the conditional variance of the portfolio return is given by $\sigma_{pt}^2 = \alpha_t^2 \sigma_t^2$, where r_{t+1} is the return on the risky asset (equities), σ_t^2 is the conditional variance of the return on the risky asset, $r_{f,t+1}$ is the return on the risk-free asset, α_t is the portfolio weight in the risky asset, and $\left(1-\alpha_t\right)$ is the corresponding portfolio weight in the risk-free asset.

Substituting the expected value of (9) and the variance of the portfolio return in (7) gives (recognising the equivalence between maximising the return and maximising the excess return):

$$(10) \qquad max \left\{ \alpha_t \left(E_t r_{t+1} - r_{f,t+1} \right) + \frac{1}{2} \alpha_t \left(1 - \alpha_t \right) \sigma_t^2 + \frac{1}{2} \left(1 - \gamma \right) \alpha_t^2 \sigma_t^2 \right\}$$

The value of α_t that maximises (10) (which will be the same as the value that maximising (7)) is given by:

$$(11) \qquad \alpha_t = \frac{E_t r_{t+1} - r_{f,t+1} + \sigma_t^2 / 2}{\gamma \sigma_t^2} \equiv \frac{ln\, E_t \left(1 + R_{t+1} \right) - ln \left(1 + R_{f,t+1} \right)}{\gamma \sigma_t^2}$$

The weight of the portfolio in the risky asset is therefore equal to the ratio of the logarithmic risk premium on the risky asset to the risk penalty on the risky asset. Given the fund manager's forecasts of the risks and returns on the assets, this tells us that the only parameter that the fund manager needs to assess in order to determine the plan member's optimal portfolio is the plan member's degree of relative risk aversion. And, as we discussed in the previous subsection, the lower the degree of risk aversion, the higher the weight in the risky asset, equities.

3.3 The equity premium

This brings us to the issue of the *equity premium* (or *equity risk premium*), the excess return on equities over the risk-free rate. This – and in particular, the 'puzzle' of why it seems to be so high[7] – has been the subject of much debate in the academic literature. Mehra and Prescott (1985) were the first to identify this 'puzzle' and suggested that the very high estimated equity premium in the US of 7.43% could only be explained if individuals had implausibly high coefficients of relative risk aversion. They argued that the risk from investing in the stock market is actually quite low given the low correlation between equity returns and consumption (the most important thing that rational economic agents are assumed to be interested in). Benartzi and Thaler (1995) show that the required coefficient of relative risk aversion

[7] Weil (1989) turned the puzzle on its head and asked why the riskless rate is so low.

is such that an investor would have to be indifferent between a bet with a 50 percent chance of $50,000 or $100,000 and a certain payoff of $51,209.

A number of studies have sought to explain the size of the equity premium without relying on investors having very high coefficients of relative risk aversion.

Kurz and Beltratti (1996) explain the size of the equity premium using a rational beliefs equilibrium (RBE) model. In an RBE model, asset price uncertainty is endogenously propagated and this is the predominant source of volatility in asset returns. Risk-averse investors need to be compensated for this and using the same parameters as in Mehra and Prescott (1985), Kurz and Beltratti are able to generate the historically observed equity premium in the US.

Constantinides et al (2002) and Kogan et al (2003) explain the size of the equity premium in terms of borrowing constraints: individuals, especially the young, would like to invest more in the stock market, but face borrowing constraints in doing so and this reduces demand and raises the return on equities above the risk-free rate sufficiently to generate the observed equity premium. Constantinides (1990) appeals to habit formation, i.e., the complementarity between consumption in adjacent periods. Using a utility function that is not time-separable – in contrast with the standard time-separable utility function used in (2) above – he shows that habit persistence drives a wedge between an individual's relative risk aversion and his intertemporal elasticity of substitution in consumption. The resulting low IES induces a strong desire for stable consumption and a corresponding low demand for equities, despite the individual not being excessively risk averse. This, in turn, sufficiently raises the return on equities above the risk-free rate to generate the observed equity premium.

Benartzi and Thaler (1995) argue that investors also often act myopically in evaluating sequences of investment opportunities. For loss-averse investors, myopia can result in the sequence looking less attractive (e.g., because of short-term mental accounting losses) and might lead to the rejection of an investment programme (e.g., a retirement savings plan invested in equities) that would otherwise be accepted. They called this *myopic loss aversion* (MLA). A symptom of MLA is excessive (i.e., very frequent) monitoring of the performance of the investment programme, even by long-term investors. If all investors behave in this way, it can have real consequences for the economy. If investors concentrated on the long-term returns on equities, they would recognise that the long-term risk on equities was no greater than that on bonds and would accept a correspondingly low equity premium (as shown in Fig. 2 below). Instead, they focus on short-term volatility and the associated frequent mental accounting losses, and demand a substantial equity premium in compensation.

Rietz (1988) argued that the size of the equity premium could be explained by low-probability disasters, the possibility that the economy and hence the stock market could be subjected to an extreme negative shock even if this possibility had a very low probability. This was consistent with both relatively low volatility in historical equity returns in countries such as the US and UK (which, unlike Germany, Japan and Italy, had not experienced the catastrophe of defeat in war, and, unlike countries in Latin America and Asia, had not experienced their scale of depressions) and rational aversion to equity ownership sufficiently high to generate the observed long-run US equity premium. Barro (2005) supports this view, and argues that a 1% annual probability of a 50% fall in GDP and the physical capital stock would be sufficient to produce the observed premium as well as the low long-run real return on risk-free government bonds, which have been particularly low in the US Civil War, World Wars 1 and 2, and the Korean War.

Faugère and Van Erlach (2006) argue that the US long-run equity premium is consistent with US GDP growth. Using a supply-side growth model, with a stable share of labour and capital in GDP, the authors show that if growth rates are stable, the real growth rate in GDP will equal the growth rate of the capital stock. They then show that, in the long-run, the unconditional expected growth of the economy's corporate capital stock equals the unconditional expected growth in the book value of a broad stock index and this completes the link between GDP growth and the equity premium. Faugère and Van Erlach also show that the equity premium is consistent with the cost of downside risk protection in the form of a put option on the S&P 500.

Brown et al (1995) and Jorion and Goetzmann (1999) explain the size of the equity premium in terms of survivorship bias, with the observed equity premium being upward biased due to the long-term survival of the markets from which they are measured. Dimson et al (2002), however, disagree with this explanation and argue that the premium in fifteen other countries in the 20th century was as large as that in the US.

Fama and French (2002) explain the high equity premium in the second half of the 20th century in terms of an unanticipated decline in discount rates. This led to a fall in the dividend-price ratio which, in turn, caused a substantial, but unanticipated, capital gain. The high observed equity premium is merely the realisation of this gain.

In short, it is not clear whether there is a genuine equity premium puzzle or not. But most recent studies (e.g., Siegel (1999), Jagannathan et al (2000), Fama and French (2002), and Poterba et al (2006)) have used much lower estimates for the future US equity premium of around 3.5% compared with the historical average between 1951 and 2000 of 7.43%. The 3.5% figure lies roughly midway between 2.55% (Fama and French (2002)'s estimate of the equity premium on the basis of long-run dividend growth rates) and 4.32% (their estimate on the basis of long-run earnings growth rates). Fama and French argue that further declines in discount rates cannot be expected to be repeated and so the expected equity premium in future needs to be consistent with perceived long-run fundamentals.

3.4 Multi-period investment strategy

Returning again to investment strategy, we note that the optimal asset allocation given by (11) is derived from a single-period model, yet a pension fund is in existence for many periods. We therefore need to extend our analysis to a multi-period setting.

Suppose then the plan member intends to retire in K periods' time. The utility function over terminal wealth is $U\left(W_{t+K}\right)$ and the budget constraint becomes:

$$(12) \qquad \begin{aligned} W_{t+K} &= \left(1+R_{pK,t+K}\right)W_t \\ &= \left(1+R_{p,t+1}\right)\left(1+R_{p,t+2}\right)...\left(1+R_{p,t+K}\right)W_t \end{aligned}$$

This implies that the cumulative log return over *K* periods is the sum of the *K* one-period returns:

(13) $$r_{pK,t+K} = r_{p,t+1} + r_{p,t+2} + ... + r_{p,t+K}$$

One special case of this problem that has received much attention is due to Samuelson (1969) and Merton (1969, 1971). They show that if two conditions hold, then it is optimal for a long-term investor, such as a pension plan member, to behave myopically in the sense of choosing the same portfolio as a short-term (i.e., one-period) investor. The first condition is that the plan member has power utility as in (2). This implies, as we saw above, that the asset allocation does not depend on current wealth and hence previous returns. The second condition is that asset returns are independent and identically distributed (i.i.d.). This implies that the mean log return on the risky asset (Er) is constant, so that the mean log *K*-period return on the risky asset is therefore KEr, the returns on the risky asset are serially independent $\left(E\left(r_{t+i} - Er\right)\left(r_{t+j} - Er\right) = 0, i \neq j\right)$, the variance of the log return on the risky asset is constant $\left(\sigma^2\right)$, and the variance of the log *K*-period return on the risky asset is:

(14) $$Var_t\, r_{K,t+K} = Var_t r_{t+1} + Var_t r_{t+2} + ... + Var_t r_{t+K} = K\sigma^2$$

When asset returns are i.i.d., any news (i.e., the unpredictable element) in asset returns $\left(r_{t+i} - Er\right)$ is uncorrelated with any news from asset returns in previous periods $\left(\left(r_{t+j} - Er\right), j < i\right)$, so will not alter the optimal asset allocation.

Now consider the simple case of *K* = 2 and two assets. The fund manager's objective is (Campbell and Viceira (2002, eqn (2.34)):

(15) $$\max\left\{E_t r_{p2,t+2} + \frac{1}{2}(1-\gamma)Var_t\, r_{p2,t+2}\right\}$$
$$= \max\left\{2r_f + \left(\alpha_t + \alpha_{t+1}\right)\left(Er - r_f + \sigma^2/2\right) - \gamma\left(\alpha_t^2 + \alpha_{t+1}^2\right)\sigma^2/2\right\}$$

This quantity is maximised when the variance term is minimised, and this occurs when $\alpha_t = \alpha_{t+1} = \alpha$, i.e., when the portfolio weights are constant over time and equal to those of a single-period investor.

Of course, in the real world, there are number of reasons why the myopic or constant-composition portfolio choice model might not be valid for long-term investors. The two main ones are the existence of time-varying investment opportunities and mean reversion in asset returns.

3.5 Time-varying investment opportunities

In the real world, the risk-free rate, the excess returns on risky assets, the variances of the returns on risky assets, and the covariances between the excess returns on risky assets are time varying or stochastic (as shown, for example, in Campbell and Viceira (2002, chapter 3)). A stochastic investment opportunity set then creates *intertemporal* *hedging demands* for those assets that are capable of hedging against adverse movements in the investment portfolio (Merton (1973)).

The presence of time-varying interest rates will create a demand for a third class of asset, apart from cash and equities, namely bonds. For example, when interest rates are expected to fall, this will reduce the income generated by the portfolio. Since the prices of long-term bonds rise when interest rates fall, long-term bonds provide a better intertemporal hedge than Treasury bills whose prices change very little when interest rates change. Only when interest rates are fixed over time is it the case that bonds are a redundant asset class: in this limited case, but only in this limited case, the optimal portfolio can be constructed exclusively using cash and equities.

3.6 Mean reversion in asset returns

There is also substantial evidence that asset returns (both the real risk-free component of the return and the risk premium) are mean-reverting.

If equity returns are mean-reverting, then an unexpectedly high return today will be offset by lower expected returns in the future. There is therefore a benefit to investing in equities over long periods in terms of reduced total variance, a benefit known as *time diversification* (or the horizon effect). Time diversification is the equivalent of risk sharing with the future, since it implies that $Var_t\, r_{K,t+K} < K\sigma^2$, i.e., that risk compounds less than linearly with time. This implies that long-horizon investors, such as pension funds, should have a 'positive hedging demand for risk (i.e., equities) at the initial stage of the game' (Gollier, 2004, p2).

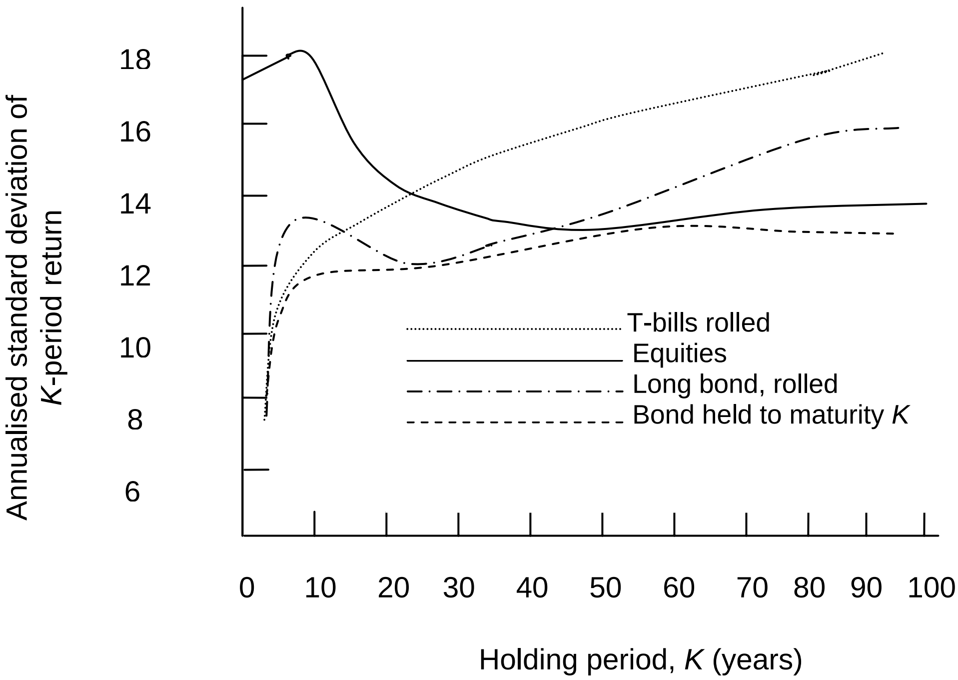

Fig. 2 Variability of multi-period asset returns in the US: 1890 – 1998
(*Source*: Campbell and Viceira (2002, Fig. 4.2a))

There is considerable evidence that equity returns are mean-reverting, see, e.g., Poterba and Summers (1988), Fama and French (1988), Blake (1996) and Balvers et al (2000).[8] Fig. 2 shows the variability of multi-period asset returns in the US and it is clear that over long investment horizons, equities are not much riskier than long-maturity bonds that are held to maturity (a view held by others such as Siegel (1997)).

3.7 Multi-period investment strategy with time-varying investment opportunities and mean reversion

Campbell and Viceira (1999) develop a model in which the return on the risk-free asset (r_f) is constant and the expected excess log return on equities is driven by a mean-reverting state variable, x_t:

$$(16) \qquad E_t r_{t+1} - r_f + \sigma_u^2/2 = x_t$$

where x_t is a first-order autoregressive (AR(1)) process:

$$(17) \qquad x_{t+1} = \mu + \phi(x_t - \mu) + \eta_{t+1}$$

where μ is the mean (or drift) of the process, ϕ the persistence parameter (with $|\phi| < 1$ in the case of mean reversion), and η_{t+1} the innovation or news element of the process which is assumed to be normally distributed with zero mean and variance, σ_η^2. The state variable, x_t, captures investment opportunities at time *t*. Hence, the covariance between the return on the risky asset and the state variable:

$$(18) \qquad Cov_t(r_{t+1}, x_{t+1}) = Cov_t(u_{t+1}, \eta_{t+1}) = \sigma_{u\eta}$$

measures the ability of the risky asset to hedge time variation in investment opportunities. In (18), u_{t+1} is the innovation in the risky asset return:

$$(19) \qquad u_{t+1} = r_{t+1} - E_t r_{t+1}$$

and is assumed to be normally distributed with zero mean and variance σ_u^2. It is also the case that:

$$(20) \qquad Cov_t(r_{t+1}, r_{t+2}) = \sigma_{u\eta}$$

Mean reversion occurs when $\sigma_{u\eta} < 0$ and it is this condition that reduces the variance of long-term equity returns, since:

[8] Not all studies support this finding, however, e.g., Kim et al (1991) and Howie and Davies (2002).

$$(21) \qquad Var_t(r_{t+1}+r_{t+2}) = 2Var_t(r_{t+1}) + 2Cov_t(r_{t+1}, r_{t+2})$$
$$= 2Var_t(r_{t+1}) + 2\sigma_{u\eta}$$
$$< 2Var_t(r_{t+1})$$

This means that the variance grows less than proportionately with the investment horizon.[9]

Campbell and Viceira (2002, eqn (4.15)) show that the optimal allocation to equities takes the form:

$$(22) \qquad \alpha_t = a_0 + a_1 x_t$$

where a_0 and a_1 are the following linear functions of $-\sigma_{u\eta}/\sigma_u^2$:

$$(23) \qquad a_0 = \left(1-\frac{1}{\gamma}\right) f_0(\mu,\phi)\left(\frac{-\sigma_{u\eta}}{\sigma_u^2}\right)$$

$$(24) \qquad a_1 = \frac{1}{\gamma\sigma_u^2} + \left(1-\frac{1}{\gamma}\right) f_1(\phi)\left(\frac{-\sigma_{u\eta}}{\sigma_u^2}\right)$$

where $f_0(.)$ is positive and increasing in μ and decreasing in ϕ, and $f_1(.)$ is positive and increasing in ϕ. For conservative investors with $\gamma > 1$, both a_0 and a_1 will be positive and increasing functions of $-\sigma_{u\eta}/\sigma_u^2$ (which is a positive quantity since $\sigma_{u\eta} < 0$). The components of a_0 and a_1 involving $-\sigma_{u\eta}/\sigma_u^2$ represent the hedging demands for equities. This means that the whole of a_0 and the second term of a_1

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[9] This contrasts with the situation in which asset returns follow a random walk (ϕ = 1 in (17)). In this case, the variance doubles if the investment horizon doubles and there is no benefit from time diversification. The table below compares the mean reversion and random walk models. Despite considerable empirical evidence to the contrary, there are a number of supporters of the random walk model of equity returns, most notably Bodie (1995).

	Mean reversion model	Random walk model
	$x_t = \phi x_{t-1} + \eta_{1t}$ $\lvert\phi\rvert < 1$ $\eta_{1t} \sim IID(0, \sigma_1^2)$	$x_t = \phi x_{t-1} + \eta_{2t}$ $\lvert\phi\rvert = 1$ $\eta_{2t} \sim IID(0, \sigma_2^2)$
Unconditional variance of x_t	Finite: $\sigma_1^2(1-\phi^2)^{-1}$	Infinite: ∞
Conditional variance of x_t	σ_1^2	σ_2^2
Autocorrelation function at lag *n*	$\phi_n = \phi^n$	$\phi_n = \sqrt{(1-n/t)} \rightarrow 1$ as $t \rightarrow \infty$
Time for mean reversion	Finite	Infinite
Memory	Temporary	Infinite

constitute hedging demands. The first term of a_1 is therefore the myopic demand. This can be seen by substituting (24), (23) and (16) into (22).

This analysis implies that conservative long-term investors will hold equities in a multi-period setting, even when the expected excess return ($E_t r_{t+1} - r_f + \sigma_u^2/2$) is zero.[10] A conservative investor will want to hedge the risk of deteriorating investment opportunities by holding assets, such as equities, that deliver excess returns when investment opportunities deteriorate. Conservative investors will therefore have a positive intertemporal hedging demand for equities even when their current forecast of the risk premium and hence their myopic demand for equities is zero.

Equation (22) also makes it clear that for conservative investors the intertemporal hedging demand moves in the same direction as the state variable, x_t. This means that the optimal strategic asset allocation is no longer fixed as it is for myopic investors. Rather, it is optimal for long-term investors to become strategic market timers and respond to forecast changes in investment opportunities.

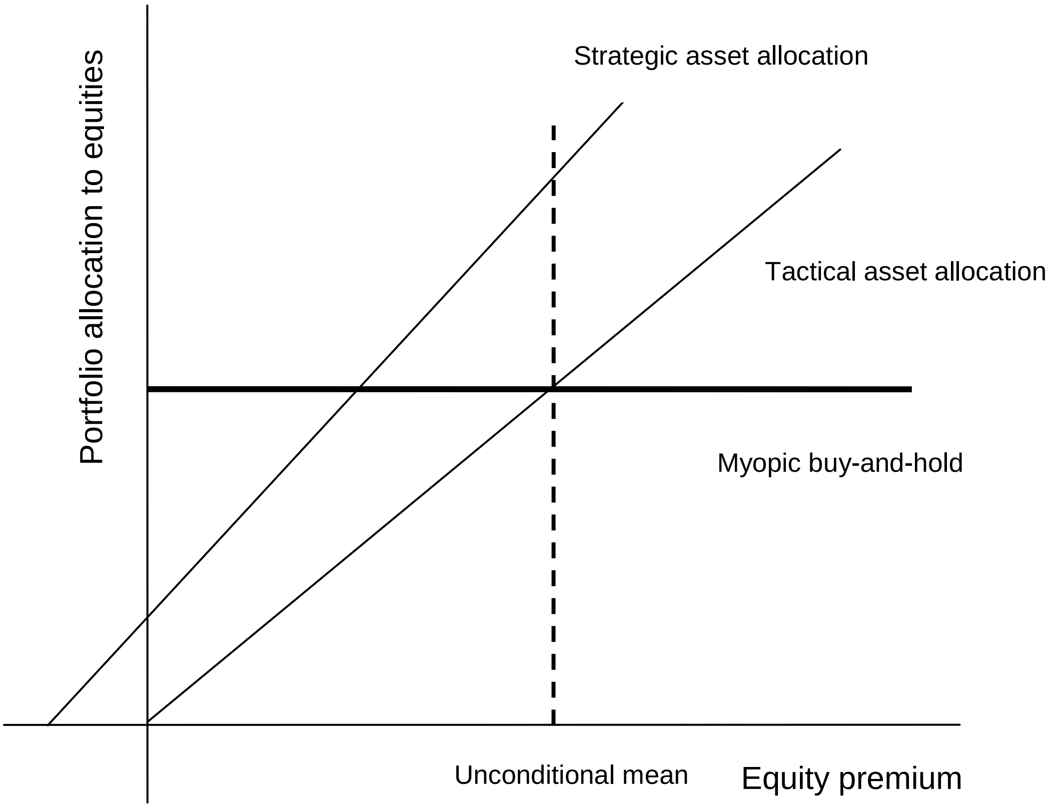

Fig. 3 Alternative portfolio rules
(Source: Campbell and Viceira (2002, Fig. 4.1))

[10] This is not true in a single-period framework as can be seen by setting the expected excess return to zero in (11).

This is shown in Fig 3. The horizontal line is the myopic buy-and-hold strategy in which the asset allocation is constant over time at a level consistent with a constant excess stock return set equal to the unconditional mean, μ. The tactical asset allocation line shows the optimal investment strategy for a myopic single-period investor who has no intertemporal hedging demand. For such an investor, $a_0 = 0$ and $a_1 = 1/\gamma\sigma_u^2$. The tactical asset allocation line passes through both the origin (confirming that a single-period investor should not hold equities if the expected excess return is zero) and the myopic buy-and-hold line where the expected excess return equals the unconditional mean. The strategic asset allocation line shows the optimal investment strategy for a long-term investor. It is higher and steeper than the tactical asset allocation line because of the presence of an intertemporal hedging demand which leads to a positive intercept and a steeper slope than in the case where there is no intertemporal hedging demand.

There are two important lessons from this section: a) equities appear to exhibit a positive long-run risk premium (although there is an ongoing debate as to its size and whether it is likely to be smaller in the future than the past) and b) equity returns appear to be mean-reverting. These, in turn, have two important implications for the strategic asset allocation of long-term investors: the first is that equities have a definite place in the portfolios of such investors; the second is that equities should not be held passively, but should be actively managed (i.e., investors should engage in market timing) in line with forecast changes in the mean-reverting state variables that drive excess returns. The most important state variables have been shown to be the short-term nominal interest rate (i.e., the yield on Treasury bills which will include an inflation premium), the dividend-price ratio, the price-earnings ratio, and the term spread between the yields on long-term bonds and Treasury bills (Campbell and Viceira (2002)). Given that these state variables are partly predictable, this implies that the excess returns on equities and hence the returns on equities themselves are (partly) predictable and this generates market timing opportunities.

Campbell and Viceira (1999) and Barberis (2000) estimate the orders of magnitude of the hedging demand when equity returns are predictable. For an investor with γ = 10 and a 10-year investment horizon, the optimal weighting in equities is 40% without predictability and 100% when there is mean reversion.

Equity returns are also predictable when the volatility of those returns is time-varying. A number of studies have shown that an increase in volatility is associated with large negative equity returns over long periods (e.g., French et al. (1987), Ghysels et al. (1996)). Chacko and Viceira (2005) show that when γ > 1, there is a negative hedging demand when changes in volatility are negatively correlated with excess returns on equities. However, the hedging demand is only significant when the shocks to volatility are sufficiently persistent.

3.8 How relevant is all this to a DC plan member?

The investment strategies discussed above are certainly more sophisticated than the kind of headline investment advice bandied about in the professional pensions trade press. For example, the *Financial Times* Monday supplement *FTfm* on 9 October 2006 had the following headlines:

- ‘Pensions turn to currency to bolster returns: Is the move into forex the latest weapon in funds’ armoury in their search for extra returns or just a passing fad?’
- ‘Pensions to increase hedge fund allocations’
- ‘Focus on total risk to seek out all sources of return: More than one route to exploit returns – Providing access to many asset classes and investment techniques is where the big fund managers are heading to attract custom’.

Such advice has virtually no relevance to someone wanting to undertake an investment strategy that targets a particular pension level in retirement. Instead it reflects what Bernstein (1992) colourfully called the ‘interior decorator fallacy’, namely the argument that portfolios should reflect attitudes to risk in the same way that interior decorators attempt to reflect the personal taste of their clients.

Even worse than the lack of relevance, professional fund managers have, by and large, tended to be ineffective in implementing the market timing strategies outlined above. Although there do exist a very small number of star fund managers who are skilled at picking winning equities (Kosowski et al (2006)), the evidence shows that the vast majority of professional fund managers produce negative returns from active fund management and, in particular, negative returns from market timing.[11]

Table 5 Performance of UK Pension Funds in Comparison with the Market, 1986-1994
(Percentages)

	Average market return	*Average pension fund return*	*Average out-performance*	*Average pension fund portfolio weight*	*Percentage out-performers*
UK equities	13.30	12.97	-0.33	53.7	44.8
International equities	11.11	11.23	0.12	19.5	39.8
UK bonds	10.35	10.76	0.41	7.6	77.3
International bonds	8.64	10.03	1.39	2.2	68.8
UK index bonds	8.22	8.12	-0.10	2.7	51.7
Cash/other investments	9.90	9.01	-0.89	4.5	59.5
UK property	9.00	9.52	0.52	8.9	39.1
Total	12.18	11.73	-0.45		42.8

Note: International property is excluded since no market index was available.
Source: Blake et al (1999; 2002, Table 2)

[11] See Lakonishok et al (1992) for evidence of this is the US and Blake et al (1999, 2002) for evidence of this is the UK.

To illustrate, Table 5 shows how well UK pension fund managers performed in comparison with other participants in the market over the period 1986–94. The fund managers considered here were managing defined benefit plans rather than defined contribution plans. However, during the period under investigation, they were managing the assets of immature plans and hence were largely unconstrained by plan liabilities. As a consequence, they were running portfolios with high equity weightings, similar in structure to the managed funds used by defined contribution pension plans. Further, the UK pension fund industry was highly concentrated at the time with the same fund management houses managing the assets of both defined benefit and defined contribution plans. We can therefore reasonably conjecture that Table 5 provides a reasonable proxy for the performance that might be expected from the managers of DC plans, data on whose performance are not publicly available. The last row of the fourth column of the table shows that the average UK pension fund underperformed the benchmark (i.e., the market average represented by the market index) by 0.45% per annum; and this was *before* the fund manager's fee is taken into account. Further, only 42.8% of funds outperformed the market average, even without taking account of mangagement fees. This underperformance in portfolio returns arises largely from underperformance in in UK equities.

Blake et al (1999, 2002) decomposed the total return generated by fund managers into the following components (using the modelling framework of Brinson et. al. (1986, 1991)):

Component	*Percentage*
Myopic buy-and-hold	99.47%
Stock picking	2.68%
Market timing	-1.64%
Other	-0.51%
Total	100.00%

Active fund managers attempt to beat the market in comparison with a myopic or passive buy-and-hold strategy (see Fig. 3). They claim that they can 'add value' through the active management of their fund's assets. Blake et al (1999, 2002) found that 99.47% of the total return generated by UK fund managers could be explained by the return on a passive portfolio invested in the market indices with average weights given in Table 5. The active components are stock picking and market timing. The average pension fund was unsuccessful at market timing, generating a negative contribution to the total return of -1.64%. The average pension fund was, however, more successful at security selection, making a positive contribution to the total return of 2.68%. But the overall contribution of active fund management was just over 1% of the average total return (or about 12 basis points), which is *less than the annual fee that active fund managers charge* (which range between 20 basis points for a £500m fund to 75 basis points for a £10m fund).[12]

Active investment performance is even worse in international markets than in domestic markets according to studies of UK pension funds' active management in international equity markets (Timmermann and Blake (2005), Blake and Timmermann (2005)). Again, using the Brinson et. al. (1986, 1991) decompositions

[12] *Pensions Management*, September 1998.

of the investment performance of a large sample of UK pension funds between 1991 and 1997, these studies show that not only do the funds underperform substantially relative to regional benchmarks (i.e., the FT/S&P indices for the four regions considered, namely Japan, North America, Europe (excluding the UK) and Asia-Pacific (excluding Japan)), but this underperformance is much larger than has been found in studies of performance in the domestic market. As with their UK investments, the results suggest that the pension funds earned negative returns from active management in their overseas portfolios (i.e., from international market timing and from selecting stocks within individual foreign regions). The average fund underperformed a passive global equity benchmark by 70 basis points per annum, which is substantially greater than UK pension funds' underperformance in their domestic equity market (33 basis points per annum, see Table 5). This underperformance was mainly due to unsuccessful market timing attempts, i.e. by systematic – and ex-post misjudged – changes in the portfolio weights across international regions.

Even those pension fund managers who do generate superior performance in certain periods find it very hard to maintain that performance over time, with the exception, as mentioned above, of a very small number of stars. Evidence for this is presented in Table 6, which shows the consistency of performance for each of three non-overlapping five-year periods achieved by a large number of UK defined benefit pension fund managers. The Table reveals that, across all three periods, only 4% of funds achieved above-average performance in each of the five years, while another 4% of funds underperformed in each of the five years. About half the funds had superior performance in three or more years and about half had below-average performance in three or more years. Comparing these figures with those in the final column confirms that this distribution is almost exactly what would be expected if above- (or below-) average performance arose entirely by chance in each year. This pattern is found consistently in each of the three five-year periods and is not affected by whether the investments considered are UK equities or more broadly based portfolios.

Table 6 Consistency of Pension Fund Performance
(Percentages)

Years above average	*Total Fund*				*UK Equities*				
	1980-84	*1985-89*	*1992-96*	*Mean*	*1980-84*	*1985-89*	*1992-96*	*Mean*	*Pure chance*
5	3	3	5	4	2	5	5	4	3
4	25	18	17	20	14	18	21	18	16
3	26	28	28	27	35	26	28	30	31
2	25	34	35	31	31	27	26	28	31
1	15	14	13	14	15	18	15	16	16
0	6	3	2	4	3	6	5	4	3

Note: The table shows the percentage of funds achieving the stated number of years of above average performance during each five-year period. The final column shows the percentages that would be expected if fund performance was purely random.

Source: CAPS *General Reports* 1985, 1989, 1996

Other studies have found some limited evidence that consistency of performance was possible, particularly in the top and bottom performance quartiles, but only over very short horizons. For example, Blake et al. (1999) found that, in the case of UK defined benefit pension fund managers, UK equity managers in the top quartile of performance in one year had a 37% chance of being in the top quartile the following year, rather than the 25% that would have been expected if relative performance arose purely by chance. Similarly, there was a 32% chance of the UK equity managers in the bottom quartile for one year being in the bottom quartile the following year. There was also evidence of some consistency in performance in the top and bottom quartiles for cash/other investments, but there was no evidence of consistency in performance for any other asset category or for the portfolio as a whole. Nor was there evidence of any consistency in performance over longer horizons than one year in any asset category or for the whole portfolio.[13] This evidence is consistent with the suggestion that so-called 'hot hands' in investment performance is a short-term phenomenon which does not persist for the extended periods.[14]

We can summarise this section as follows:

- The fund manager in designing the strategic asset allocation during the accumulation stage of a pension plan should take into account the plan member's degree of risk aversion
- There is a positive equity premium, i.e., over long investment horizons, the expected return on equities exceeds the return on cash
- There is evidence that equity returns revert to their mean
- In a multi-period investment strategy, it is optimal to time the market; this is because the relationship between the returns on different assets varies over time and this creates an intertemporal hedging demand for equities.
- However, market timing is difficult to do successfully, and most fund managers are bad at it.

What should the designer of the investment strategy of a DC pension plan make of this? On the one hand, in a multi-period setting, he is told that it is optimal to engage in strategic market timing. But, on the other, there is little evidence that professional pension fund managers have been successful at timing markets, either domestically or internationally. So we are left with a conundrum. We need to return to our airline analogy for guidance.

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[13] Lunde et al (1999) found similar results for mutual funds (a typical investment vehicle for DC pension plan members): for example, a mutual fund specialising in UK equity which was in the top quartile in one year had a 33% chance of remaining in the top quartile the following year, while there was a 36% chance of it remaining in the bottom quartile for two consecutive years.

[14] Very similar results have been found in the US (see Grinblatt and Titman (1992), Hendricks *et al.* (1993), Brown and Goetzmann (1995), and Carhart (1997)). For example, Carhart (1997) argues that the short-term persistence effect discovered by Hendricks *et al.* (1993) is mostly driven by the one-year momentum effect identified by Jegadeesh and Titman (1993). However, individual funds do not, on average, earn higher returns from following a momentum strategy, but rather because they happen by chance to hold relatively large positions in the previous year's winning stocks. The only persistence that is significant is concentrated in strong underperformance by the worst-return mutual funds. Carhart's findings do not therefore support the existence of skilled or informed mutual fund portfolio managers because: 'hot hands' funds infrequently repeat their abnormal performance; transactions costs consume gains from following a momentum strategy in stocks; and expense ratios, portfolio turnover costs and load fees are significant and negatively related to performance. Tonks (2005) finds some evidence of one-year persistence in UK pension funds' performance over the period 1983-97 even after allowing for a momentum effect, but that this persistence is much weaker over longer investment horizons.

4. How similar are pension plans and commercial airline journeys?

When you think about it, there is much in common between a pension plan and a commercial airline journey. The strategic investment strategy of a pension plan is analogous to the aircraft. The aircraft operator is analogous to the pension plan provider. The contributions into a pension plan are analogous to the aircraft's fuel. The climb stage of an aircraft's journey is analogous to the accumulation stage of a pension plan, and the aircaft's descent stage is analogous to the pension plan's decumulation stage. The actions of the pilot in managing the progress of the flight (e.g., in dealing with turbulence and cross winds) are analogous to the market timing or tactical asset allocation decisions of the fund manager. Air traffic controllers play the same role as pension regulators.

This comparision indicates some clear similarities between airline journeys and pension plans:

- Both seek to get you to a destination: in one case, a safe landing, in the other case, a comfortable retirement until death
- Both involve the commitment of significant resources
- Both involve managing risks
- Both involve a climb and a descent stage.

However, there are also some very significant differences, and these differences are also highly instructive.

To start with, there is no uncertainty about the destination of an airline journey and the passenger does not – and indeed cannot – change his or her mind once the journey has started. By contrast, with a pension plan, both the destination of the journey (how much pension is desired in retirement) and the anticipated length of the journey (the member's retirement lifespan) are generally much less clearly formulated when the pension plan journey begins. This gives a greater opportunity for the member to change his mind over decisions such as the retirement date or over whether a lump sum or annuity is required at retirement. The retirement and annuity decisions can also take place at different times. The need to accommodate this additional choice flexibility makes the design of the investment strategy much more complicated than the design of an aircraft.

The time horizon with an airline journey is also much shorter, typically a few hours, compared with the 70-year or so journey of a pension plan. Aircraft designers *must* get the design right *before* the aircraft ever takes off, otherwise they will lose their reputation, job or worse. By contrast, the designers of pension plans will have long departed the scene by the time the member discovers whether his plan was well designed or not.

Another important difference is that airline passengers know that they need to get to the airport by a certain time if they want to catch their plane and reach their destination in time. On the other hand, the much longer journey of a pension plan offers plenty of opportunities to delay the journey's start and consequently to end up with a lower pension by the time the retirement date arrives. There are behavioural explanations for delaying pension saving (which we consider in section 6 below), but there might also be rational reasons. For example, young people might have debts to pay off, mortgages to pay or children to bring up. They might also rationally anticipate higher income in middle age which would enable saving for retirement to begin much later in the life cycle or they might be willing to work longer before retiring if they discover that they would otherwise live in poverty. The pension plan is just one part of an individual's life cycle financial plan and there are other factors to take into account, such as the desire to make a bequest to one's children (which influences the demand for life annuities in retirement) and the existence of social security (which influences the demand to save privately for retirement). In comparison, an airline journey is a one-off event that rarely impinges on other aspects of an individual's life.

Yet another difference lies in the fact that the laws of aerodynamics are known and unchanging, whereas our understanding of the processes generating asset returns are still poorly understood. No one would expect an individual contemplating an airline journey to have a deep understanding of the laws of aerodynamics, yet individuals considering joining a defined contribution pension plan are expected to make very complex investment choices that implicitly presuppose a knowledge of asset return processes that even experts do not have.

There is also virtually no danger of an aircraft having insufficient fuel to reach its destination. Although there is a clear tradeoff in the design of a commercial airline between fuel efficiency and GTOW, there are very, very few cases of aircraft crashes caused by running out of fuel. And, of course, it is very obvious with a commercial airline flight that no improvement in fuel efficiency can compensate for insufficient fuel to reach the destination. Indeed, with an aircraft it is unthinkable to consider possible improvements in fuel efficiency in order to compensate for fundamentally inadequate fuel provision. For its part, a pension plan does involve an important tradeoff between investment strategy and contributions: a low-risk investment strategy with high but stable contributions, on the one hand, or a higher-risk investment strategy with lower but more volatile contributions, on the other. Nevertheless, as with airline fuel, we would argue that no increase in investment risk can compensate for fundamentally inadequate contributions if a particular target replacement ratio in retirement is desired. This to us is one of the key problems in the design of current pension plans: the misguided attempt to use investment strategy to compensate for fundamentally inadequate contributions.

Another subtle but important difference relates to economies of scale. Such economies are an integral feature of the design of a commercial aircraft: they are essential to keep prices down and demand high. While the super rich can afford their own jumbo jets, there is no feasible mass market for single individual commercial airline flights. With pensions, on the other hand, there is a large market for personal DC plans, but these plans are very expensive in terms of charge extraction via reduction in yield, especially if the plans are voluntary and have to be marketed directly to individuals separately. Two ways around this are auto-enrolment in a worked-based DC plans (discussed in more detail in section 6 below) or mandatory participation in a government-sponsored plan, such as the Swedish Premium Pension System.

A final difference relates to the relationship between the climb and descent stages of an aircraft journey, on the one hand, and the accumulation and descent stages of a DC pension plan, on the other. Whereas the climb and descent stages of an aircraft journey make up a seamless whole, there is an almost complete lack of integration of the accumulation and decumulation stages in the current design of DC pension plans. We put this down to the absence of an effective target replacement ratio[15] in a DC plan. The fund manager takes whatever contributions he receives and invests them in line with the declared level of risk aversion he is told that the plan member has. He has no incentive to deliver any specific fund level, since he has been set no target to do so. At the start of the decumulation stage, the assets are typically handed over to a life assurer and, depending on the size of this lump sum, the age and sex of the member and whether or not a spouse's pension is also required, the life assurer provides a life annuity to the member.[16] Again the life assurer has no incentive to deliver any specific replacement ratio in retirement, since again he has been set no target to do so. All this contrasts markedly with the design of an aircraft where the climb and descent stages are an integral part of the overall design because the aircraft is designed for the ultimate purpose of reaching a destination safely. Imagine being told by the captain of the 'climb plane' that it is time for you to transfer to the 'descent plane' as he is running out of fuel and has to turn back, but that the 'descent plane' is 1,000 metres above him!

Although there are clear differences between commercial airline journeys and pension plans, none of them seriously undermines the usefulness of the analogy and even the differences are instructive for good pension plan design We would therefore draw the following important lesson for the design of a pension plan. A well-designed pension plan is, like a successful airline journey, one that is designed from back to front, with the destination – an adequate pension in retirement until death – being at the forefront of the design. Current pension plans are far from this ideal and are not currently designed at all well: they are currently 'designed' from front to back, beginning with the question 'how much would you like to contribute to your pension plan?' before going on to frighten off potential members with the next question 'what is your attitude to risk?'. No wonder pension savings are so low!

5. How can we apply these lessons to the design of DC pension plans?

> *Like an aircraft journey, a DC pension plan must be designed from back to front from desired output – a desired life-long consumption stream in retirement – to required inputs, particularly the contribution amount and investment strategy. Other factors that need to be taken into account include the target retirement date, the value of the plan member's human capital (especially when human capital can be adjusted via flexibility in the member's supply of labour) and housing wealth. When human capital and housing wealth are taken into account, the optimal initial investment in equities is higher than when it is not (in order to counterbalance these bond-like assets). The higher equity weighting will result in pension wealth being more volatile and if it falls short of the level needed to provide an adequate retirement income, the plan member must be prepared to contribute more or retire later. The optimal weight in equities declines over time as pension wealth increases. Full implementation of the optimal accumulation-stage*

[15] That is, a ratio of pension to final salary.

[16] Any 'pension plan' that does not involve (at least partial) annuitisation at some stage is not a genuine pension plan, merely an asset accumulation plan, since it does not hedge longevity risk (the risk of running out of resources before the plan member dies), one of the key risks that a proper pension plan needs to insure against.

investment strategy, stochastic lifestyling, is difficult and some simpler solutions are considered: deterministic lifestyling, threshold and portfolio insurance. At some point, the member will retire and draw down his accumulated pension wealth. At least some of this needs to be in the form of a life annuity in order to hedge against longevity risk. The decision about when to annuitise can be thought of as an option and will depend on the survival credit, the degree of risk aversion, annuity income risk, and the fund size. The decision about how much to annuitise depends on such factors as the size of the state pension, the equity premium, the member's health status and the desire to make a bequest. As in the accumulation stage, full implementation of the optimal decumulation-stage investment strategy is difficult and some investment-linked retirement-income programmes that try to deal with some of these factors are considered. Stripped down to its bare essentials, a simplified DC plan would involve a deterministic lifestyling investment strategy during the accumulation stage and an index-linked life annuity purchased with the accumulated fund on the retirement date.

Of the two stages of a DC pension plan, it is the decumulation or descent stage of the pension plan journey that is – or should be – of most interest to the pension plan member. It is on the descent journey that the plan member discovers whether or not he has been a member of a good pension plan or not. The test will be whether he enjoys a satisfactory standard of living in retirement.

If a pension plan is designed from back to front, then the following key factors need to be taken into account:

- The consumption profile desired by the plan member from his pension plan
- The target date for drawing a pension from the plan: this might be, but need not be, the same date as the member's retirement date
- The value of the fund needed to deliver the desired consumption profile at the target date
- The vehicle for delivering the pension: this can either be a life annuity or an income drawdown (or systematic withdrawal) facility from the fund which remains invested in the stock market
- The contribution amount and investment strategy needed during the accumulation stage to build up the required lump sum, taking into account the plan member's attitude to risk
- The value of the plan member's human capital, which is defined as the discounted present value of lifetime labour income. This is needed to determine both the required value of the fund at the retirement date and the required contribution amount during the accumulation stage.

The first question we need to ask therefore is what consumption profile do pension plan members desire in retirement? The expected present value of this consumption profile gives the value of the fund that needs to be accumulated by the retirement date. Then working backwards we need to find the combination of plan contributions and investment strategy that are most likely to deliver that pension, taking into account the plan member's attitude to risk.[17]

[17] The technical term for this design process is dynamic programming.

5.1 What type of consumption profile do members want from their pension plan?

The life cycle model (LCM) of Ando and Modigliani (1963) predicts that individuals prefer a smooth consumption profile over time and will plan to run down their assets to zero over the course of their life cycle. Fig. 4 shows one particular profile for consumption, labour income, pension wealth and other (principally financial) wealth over an individual's life cycle (in the absence of a bequest motive). In this case, the individual retires at 65 and the pension wealth is converted into an index-linked lifetime annuity. This provides for a retirement income that is initially lower than pre-retirement income, but gradually rises over time. Consumption during the period just after retirement is sustained by drawing down financial assets. The result is that consumption over the lifecycle is smoother than income over the lifecycle.[18]

But do individuals prefer a fairly steady profile over time as shown in Fig. 4, an upward sloping profile or a downward sloping profile? Frank and Hutchens (1993) and Matsumoto et al (2000) offer evidence indicating that, during the working life, individuals tend to prefer a rising profile of consumption relative to wages. But what preferences do people expect to have when they are retired?

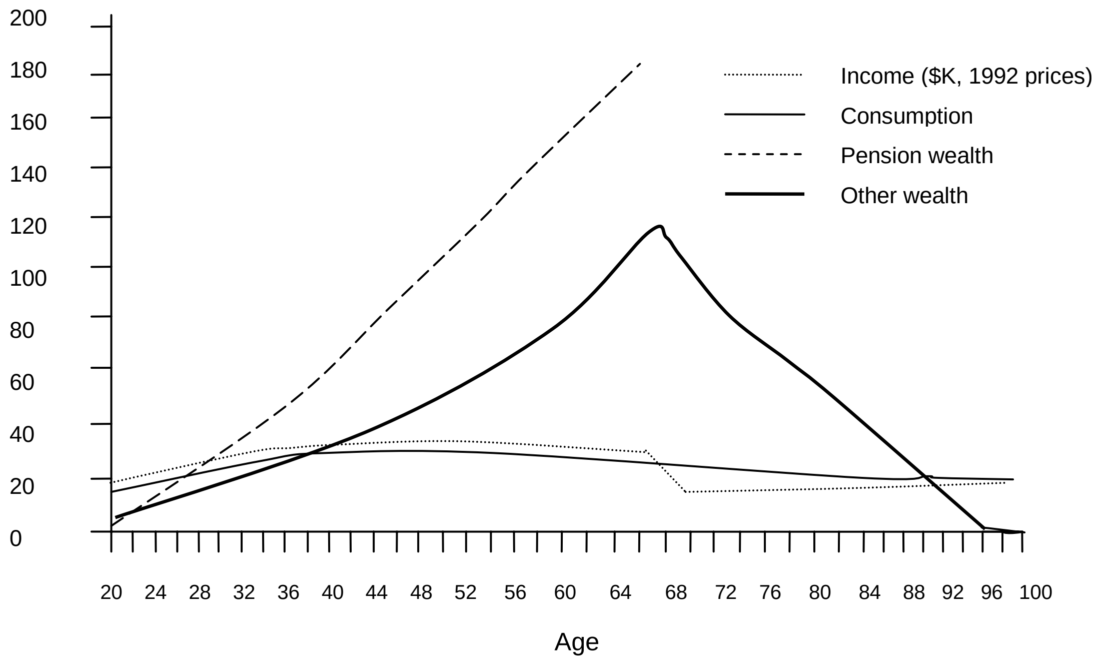
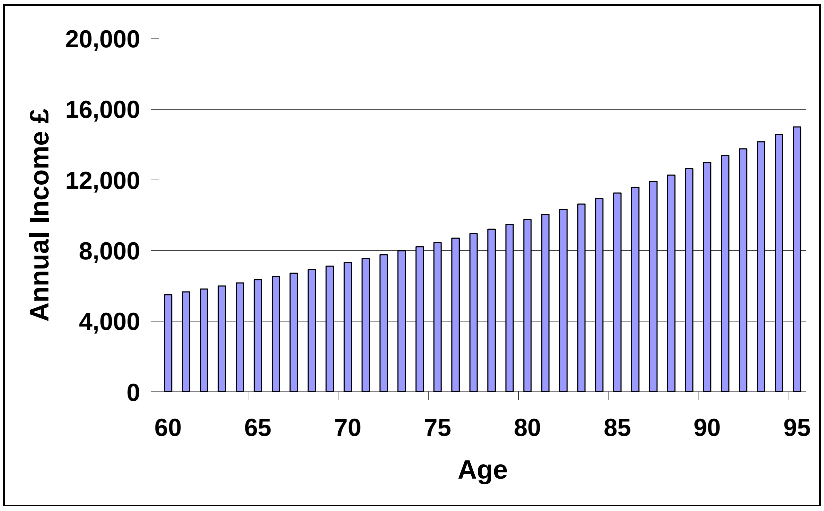


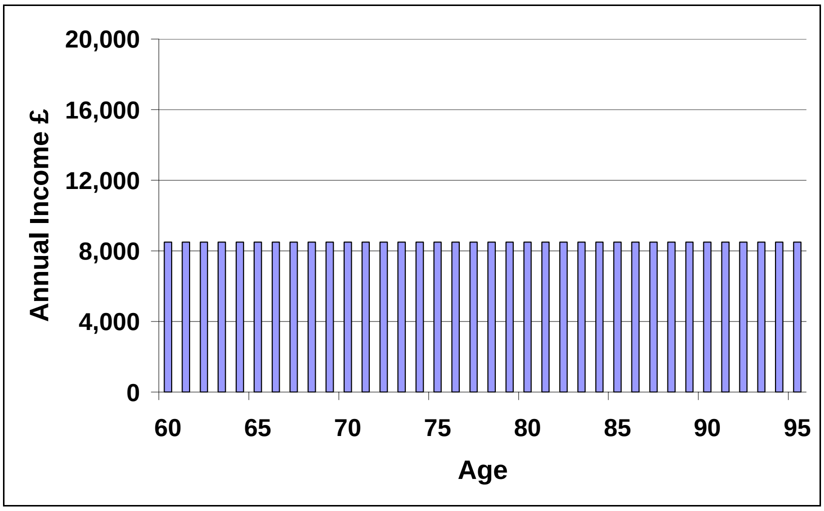
Fig. 4 Lifetime profiles of income, consumption and wealth
(Source: Campbell and Viceira (2002, Fig. 7.2))

[18] This was one of the empirical observations that led to the development of the life cycle model.

Option 1: Pension *slowly rises* in real terms



Option 2: Pension *remains the same* in real terms



Option 3: Pension *slowly falls* in real terms

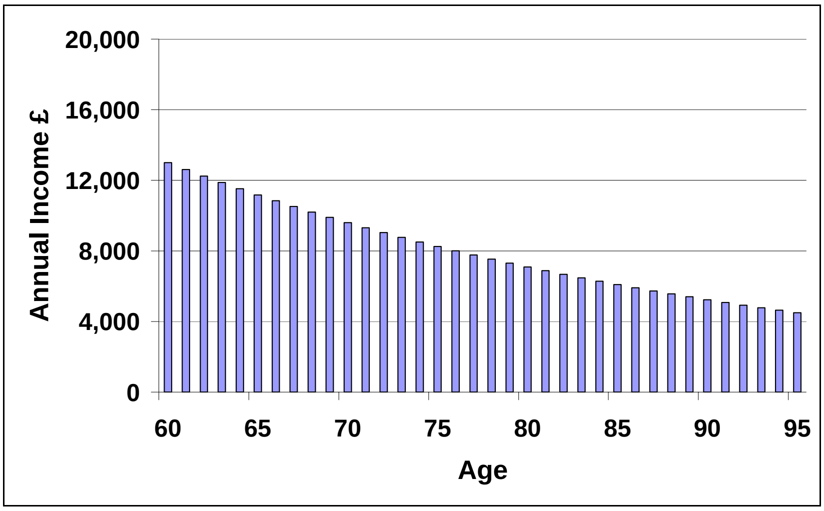


Fig. 5 Possible income profiles in retirement
(*Source:* Keasey et al (2006))

The answer varies with the individual. Some possible insights into this issue are suggested by Keasey et al (2006), who present the results of a survey that specifically asks this question.[19] Respondents came from all age and wealth levels and were shown the three charts in Fig. 5. They were told that the income profile in each graph is inflation-adjusted and has the same discounted present value and so would cost the same to purchase. They were asked to rate how attractive each option was to them using a 0 to 10 scale with 0 meaning 'not at all attractive' and 10 meaning 'very attractive'.

The mean attractiveness of the rising, steady and falling profiles were 6.14, 5.41 and 3.02 respectively. Table 7 presents reasons for these preferences. The main explanation given by those preferring a rising profile is the need for higher expenses when older,[20] while the main explanation for preferring a falling profile is the desire to enjoy spending more money when younger. Those preferring a steady profile felt that it was easier to budget and plan with this profile.

Table 7 Cross-tabulation of stated reasons for preference and actual preference of patterns of income streams

	Income stream			Total
Stated reason	Rising	Steady	Falling	24
Enjoy money more when younger (or less when older)	1	7	16	
Own life expectancy (low/high)	1	5	4	10
Higher needs/expenses when very old	27	2	2	31
Not able to live on initial amount	1	2	1	4
Just prefer a rise	15	3	0	18
Lower needs/expenses when very old	0	2	11	13
Earn more when younger	1	0	0	1
References to risk	0	2	0	2
Easier to budget/plan	2	8	0	10
Inflation	35	7	1	43
Total	83	37	35	156

Source: Keasey et al (2006, Table 5)

5.2 The accumulation stage

Then there is the question of the how contributions during the accumulation stage should be invested. The answer depends, in part, on issues such as the plan member's degree of risk aversion, as suggested earlier, but also on the riskiness of his labour income and hence human capital; and it depends too on whether there are other *background risks* to take into account.

[19] The survey is the Financial Well-being Survey developed by the International Institute of Banking & Financial Services (IIBFS): see Ironfield-Smith et al (2005).

[20] The most common explanation for preferring a rising income profile is inflation, but this is inconsistent with the charts which show income expressed in real terms; so it might be the case that some respondents did not understand fully the question they were asked.

5.2.1 Labour income

A key factor ignored by the investment strategies discussed in section 2 is that the contributions into the plan must be paid out of labour income. This, in turn, raises the issue of the plan member's career salary profile. To illustrate what these look like, Figures 6 and 7 show some typical career salary profiles for different male and female occupational groups in the UK (extracting from productivity improvements and expected inflation). The profiles have been rescaled to give a value of unity on the retirement date which for both males and females has been set at 60; thus, the final salary for each occupation has been rescaled to unity.

The shape of the career salary profile can have a dramatic effect on the size of the pension as Blake et al. (2007) have documented. This study suggests that the career salary profile is driven by two key parameters, namely relative career average salary (RCAS) and peak salary age (PSA). The study shows that DC pension plans benefit most those workers who have the highest career average salary relative to final salary and/or those whose salary peaks earliest in their careers.

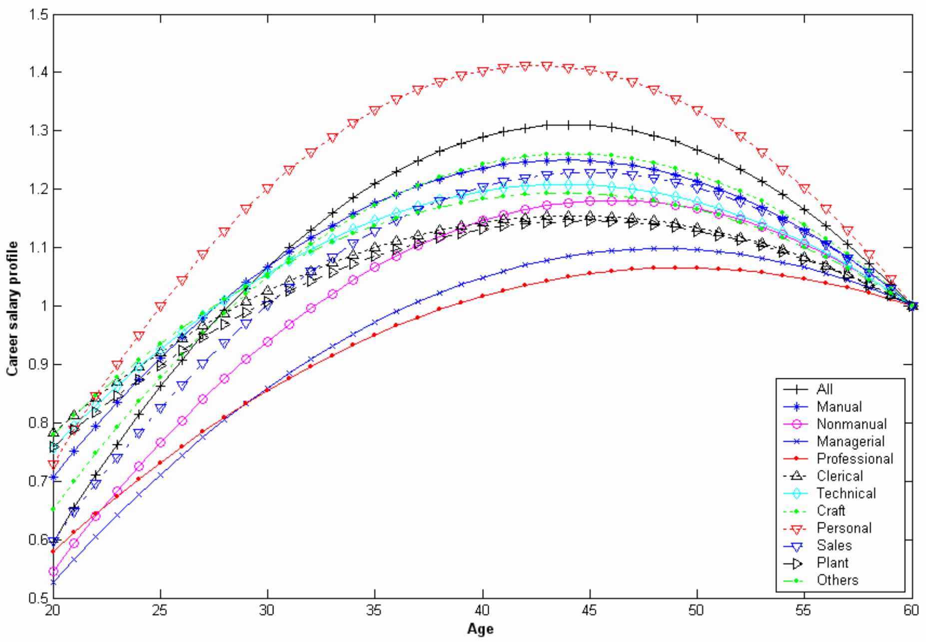


Fig. 6 Career salary profiles for male workers in the UK
(Source: Blake et al (2007, Fig.1))

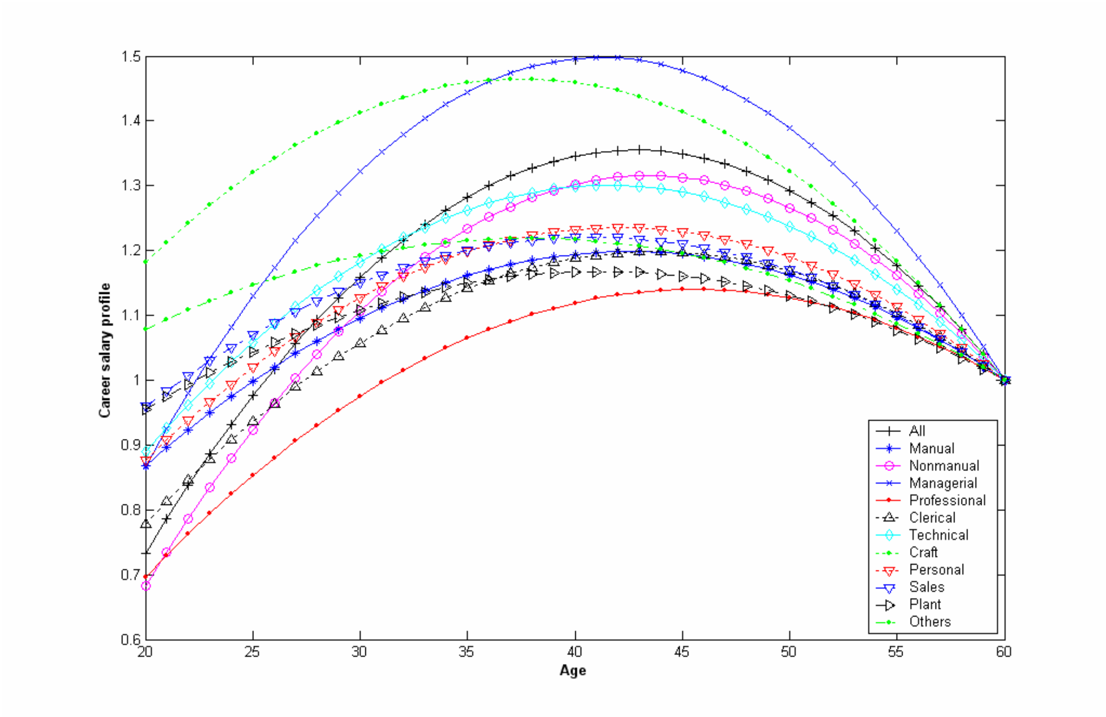


Fig. 7 Career salary profiles for female workers in the UK
(Source: Blake et al (2007, Fig.1))

Thus low-skilled workers and women do *relatively* well from DC plans (that is, relative to final salary). Blake et al. (2007) show that, in the case of an equities-only investment strategy, the largest median pension-to-final-salary difference between occupations is 34% for men and 38% for women, for the same contribution rate as a proportion of salary. Male personal service workers have a 34% higher pension (relative to final salary) than male professionals whose incomes peak much later in their careers. The largest median pension-to-final-salary difference between women and men in the same occupation (managerial workers) is 45%. The implication is that there are major differences across both occupation and gender, and this suggests that key aspects of a DC pension plan design (in particular contribution rates) should be occupation- and gender-specific.

5.2.2 The optimal investment strategy with riskless labour income

Now consider how the optimal asset allocation in the accumulation stage is determined when labour income is assumed to be riskless.[21] In this case, human capital (H_t) is measured as the present value of future labour income discounted at the riskless rate.

Following Campbell and Viceira (2002, chapter 6), the plan member then treats human capital as one of his riskless assets. Total long-term assets are now the sum of financial assets (which are assumed to be held in the pension plan) and human capital $(W_t + H_t)$. The optimal asset allocation in the presence of human capital is found by

[21] One implication of this is that future contributions to a DC pension plan are perfectly hedgeable, i.e., an individual could borrow now against these promised contributions and be 100% sure of repaying the 'loan', provided he hedged appropriately.

investing (in the case of unchanging investment opportunities) $\alpha\left(W_t+H_t\right)$ dollars in equities and $\left(1-\alpha\right)\left(W_t+H_t\right)-H_t$ dollars in the riskless asset. This implies that the optimal share of equities in financial assets is (Campbell and Viceira (2002, equation (6.1))):

$$\begin{aligned}(25)\qquad \hat{\alpha}_t &= \frac{\alpha\left(W_t+H_t\right)}{W_t} \\ &= \frac{Er-r_f+\sigma^2/2}{\gamma\sigma^2}\left(1+\frac{H_t}{W_t}\right) \\ &= \frac{Er-r_f+\sigma^2/2}{\gamma\sigma^2}+\frac{Er-r_f+\sigma^2/2}{\gamma\sigma^2}\left(\frac{H_t}{W_t}\right)\end{aligned}$$

It is possible that the optimal dollar investment in the riskless asset might be negative, which implies that the investor takes a leveraged position in equities, i.e., he might borrow at the riskless rate to invest in the stock market.

It is also clear that $\hat{\alpha}_t \geq \alpha$, the optimal investment in equities, is higher when an investor has human capital than when he does not. It is also optimal for the weight in equities to decline over time as human capital is depleted and financial wealth grows. Early in adult life, the ratio $\left(H_t/W_t\right)$ is likely to be very high because the individual's human capital is high and his accumulated financial wealth is likely to be low. Over time, this ratio falls and so does the optimal investment in equities. The move away from equities also accelerates, the better that equities perform. The optimal strategy is therefore dynamic (with a trend decline in equities over time), but also contrarian (i.e., he disinvests from equities the stronger the returns on equities are high). We can also see that the optimal allocation has two components, a myopic or static component and an intertemporal hedging component that depends on $\left(H_t/W_t\right)$. Fig. 8 shows a particular realisation of this strategy for γ = 5.

The required contribution amount and its volatility over time will depend on H_t, W_t and $\hat{\alpha}_t$. A higher H_t means that a higher pension fund is needed to sustain an adequate retirement lifestyle, and this requires a higher contribution amount as a proportion of W_t. A higher $\hat{\alpha}_t$ implies a more volatile contribution amount over time as it needs to adjust in the light of realised investment performance to meet the required pension fund: for example, if there is a big fall in equity prices, the contribution amount would have to increase to compensate and vice versa.[22]

[22] The determination of the optimal contribution amount in a DC plan is beyond the scope of this paper, although we recognise that it will be intimately linked to both the investment strategy chosen and the funding status (i.e., whether the plan is in surplus or deficit). These issues are examined by Haberman and Sung (1994).

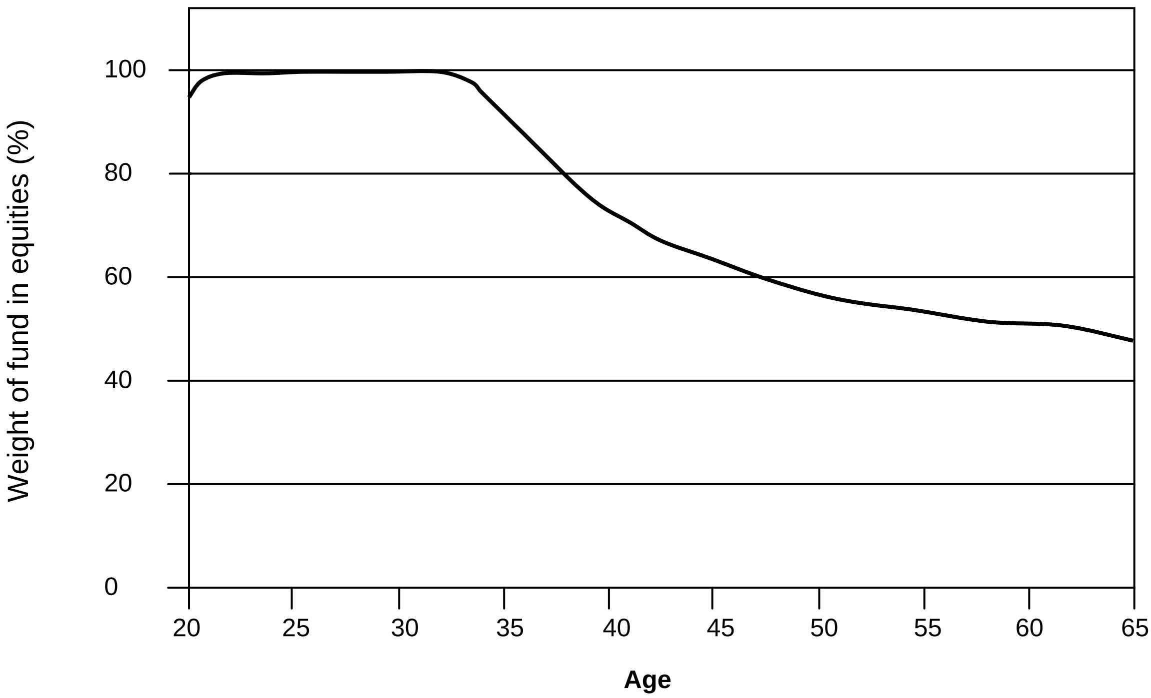


Fig. 8 The optimal weight in equities in the presence of labour income
(Source: Gomes and Michaelides (2005, Fig. 2B))

5.2.3 The optimal investment strategy with risky labour income

In reality, of course, future labour income is not riskless: rather, it is both volatile and correlated with the returns on risky financial assets. Risky labour income is an example of a *background risk*, that is, a risk that is not under the individual's control and which is not directly related to the investment strategy itself, but which nevertheless influences the outcome of the investment strategy.[23]

Campbell and Viceira (2002, equation (6.11)) show that the optimal share of equities in the portfolio when labour income risk is taken into account is given by:

$$(26) \qquad \hat{\alpha}_t = \frac{1}{\rho}\left(\frac{Er - r_f + \sigma_u^2/2}{\gamma\sigma_u^2}\right) + \left(1 - \frac{1}{\rho}\right)\left(\frac{\sigma_{ul}}{\sigma_u^2}\right)$$

where σ_u^2 is the variance in the innovation in the risky asset return (19), and σ_{ul} is the conditional covariance between the return on the risky asset and the logarithm of labour income (i.e., $Cov_t\left(r_{t+1}, l_{t+1}\right) = \sigma_{ul}$), where $l_{t+1} = ln\left(L_{t+1}\right) \sim N\left(l, \sigma_l^2\right)$ and L_{t+1} is labour income in period $t+1$. In (26),

$$(27) \qquad \frac{1}{\rho} = 1 + \overline{H/W}$$

[23] It means, in particular, that the present value of future pension contributions can no longer be treated as a default-free loan as in the previous sub-section.

where $\overline{H/W}$ is the average human capital to financial wealth ratio over the working life. Campbell and Viceira (2002, p169) show that ρ has a natural interpretation as the elasticity of consumption with respect to financial wealth, while $(1-\rho)$ is the elasticity of consumption with respect to labour income.

Unfortunately, investors cannot trade away (i.e., hedge) labour income risk for the simple reason that human capital is a non-tradeable asset, i.e., individuals cannot sell their human capital. One reason for this is the obvious one that this is tantamount to slavery which is illegal. But a second reason is that there would be an immediate moral hazard problem if they did: having received the proceeds from the sale of their human capital, individuals would have a much reduced incentive to provide the future labour they have promised. This explains the additional hedging demand for equities given by the second term in (26).

In any case, labour supply is not fixed over time as implicitly assumed so far. People can choose how much labour to supply each year (N_{t+1}) in the light of the real wage that they are offered that year (Z_{t+1}). They also have some choice about how long to work. The choice of retirement date might be affected by both employment and portfolio developments, as emphasised by Bodie et al (1992). For example, if the accruing pension fund is insufficient to support an adequate pension in retirement, say because of poor investment performance or because the plan member was unemployed for a significant period, a plan member might delay retirement and work longer. On the other hand, an outstanding investment performance might induce earlier retirement. We shall come back to the timing-of-retirement issue shortly.

When labour supply is endogenous, Campbell and Viceira (2002, equation (6.27)) go on to show that the optimal share of equities in the portfolio is given by:

$$(28) \qquad \hat{\alpha}_t = \frac{1}{\beta_w}\left(\frac{Er - r_f + \sigma_u^2/2}{\gamma\sigma_u^2}\right) - \frac{\beta_z}{\beta_w}\left(\frac{\sigma_{uz}}{\sigma_u^2}\right)$$

where σ_u^2 is, as before, the variance in the innovation in the risky asset return (19), and σ_{uz} is the conditional covariance between the return on the risky asset and the logarithm of the real wage (i.e., $Cov_t(r_{t+1}, z_{t+1}) = \sigma_{uz}$). In (28),

$$(29) \qquad \beta_w = \frac{\rho}{1+(1-\rho)\gamma\nu} \in (0,\rho)$$

$$(30) \qquad \beta_z = \frac{(1-\rho)(1+\nu)}{1+(1-\rho)\gamma\nu}$$

where ν is the elasticity of labour supply with respect to the real wage.[24] Comparing (28) and (26), and recognising that $\beta_w \leq \rho$, it is clear that the flexibility to adjust labour supply over time increases the weight of equities in the portfolio if wages are uncorrelated with equity returns. However, if wages are positively correlated with equity returns, this flexibility will lead to a reduction in the weight of equities in the portfolio. The explanation is that when labour supply is flexible, labour income is highly responsive to wage shocks (a cut in wage rates reduces hours worked along the supply curve for labour and so labour income falls for two reasons, namely a cut in the wage rate and a cut in hours worked). Investors with flexible labour supply are therefore keen to hedge wage risk and do so by adjusting their equity holdings.

This analysis has been generalised by Cairns et al. (2006a) to allow for annuity risk, which in their model arises from a time-varying riskless interest rate. Annuities will be discussed in more detail below, but for now the key point to take into account is that the price of annuities is inversely related to the interest rate. Annuity risk can be hedged using a third asset class, bonds, in addition to equities and cash: bonds are a good hedge for annuity risk because they also vary inversely with interest rates.

This leads to an optimal strategy that Cairns et al. (2006a) call *stochastic lifestyling*. This strategy requires three funds, an 'equities' fund, a 'bond' fund and a 'cash' fund.[25] Assuming a Vasicek (1977) model of stochastic interest rates with a mean reversion term given by $\kappa\left(Er_f - r_{f,t}\right)$, where κ measures the speed of adjustment of the actual interest rate, $r_{f,t}$, back to the equilibrium rate, Er_f, Cairns et al. show that the optimal weight in the 'equities' fund at time *t* is:

$$(31) \qquad \bar{\alpha}_t = \frac{W_t + \Pi_t}{\gamma W_t}$$

where W_t is accruing pension wealth and Π_t is the present value of future contributions into the pension plan.[26] The weight in equities will start out very high because W_t starts out very low and Π_t starts out very high. However, as Π_t falls over time relative to W_t, then $\bar{\alpha}_t$ will fall. For its part, the optimal weight in the 'bond' fund is given by:

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[24] As ν tends to zero, the labour supplied becomes fixed independent of the real wage and $\beta_w = \rho$ and $\beta_z = (1-\rho)$ and (28) approaches (26). As ν tends to infinity, the labour supplied becomes infinitely elastic and $\beta_w = 0$ and $\beta_z = 1/\gamma$.

[25] These funds are dominated by equities, bonds and cash, respectively, but each fund contains some of the other assets in order to hedge intertemporal shifts in investment opportunities, interest rate volatility and correlation with labour income. For example, the 'equities' fund is an efficient portfolio of equities (mainly), bonds and cash, with the weights in the risky assets depending on the ratios of the assets' risk premium to return variance in the standard fashion; the weights are then adjusted to account for the correlation between asset returns and labour income. For more details, see Cairns et al. (2006a). More sophisticated versions of the 'equities' fund might involve *diversified growth* or *new balanced funds.* These are funds that invest across a range of traditional and generally non-correlated alternative asset classes, such as private equity, commodities and infrastructure. This asset allocation, which aims to reduce risk and volatility, contrasts with 'old' balanced funds, which typically have approximately 80-85% invested in listed equities. For more details, see Byrne et al. (2007).

[26] This will be proportional to human capital if the contribution rate is constant.

$$(32) \qquad \bar{\alpha}_{Bt} = \frac{(\gamma - 1)(W_t + \Pi_t)e^{-\kappa(T-t)}}{\gamma W_t}$$

where T is the retirement date. Again this starts out very high, but falls very rapidly and then rises steadily over time. And, finally, the optimal weight in the 'cash' fund is given by:

$$(33) \qquad \bar{\alpha}_{Ct} = 1 - \bar{\alpha}_t - \bar{\alpha}_{Bt}$$

$$= -\frac{\Pi_t}{W} + \frac{(\gamma - 1)(W_t + \Pi_t)\left(1 - e^{-\kappa(T-t)}\right)}{\gamma W_t}$$

As mentioned above, the optimal weight in the 'cash' fund can starts out highly negative: cash is borrowed to finance highly leveraged positions in equities and bonds. The cash weighting then rises over time and becomes positive after a few years, before falling back to zero as the retirement date approaches.

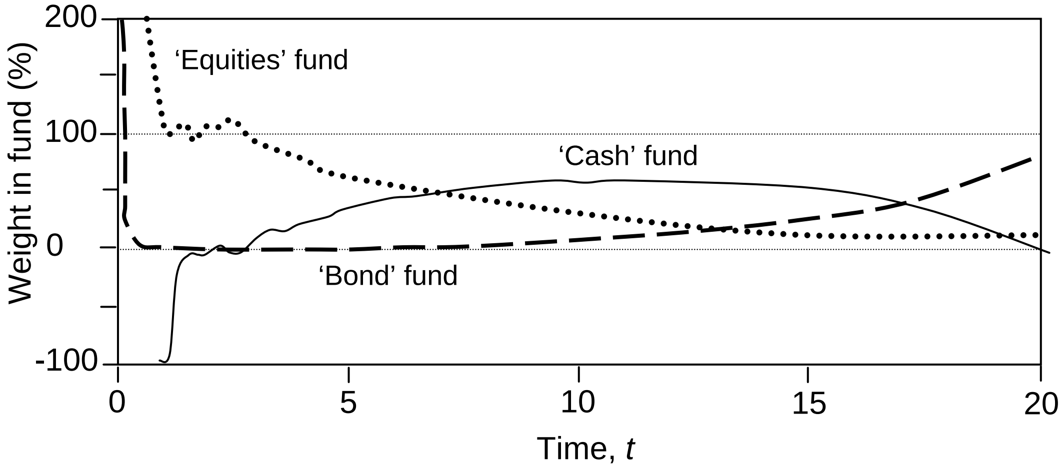

Fig. 9 Stochastic lifestyling when γ = 6
(Source: Cairns et al. (2006, Fig. 5))

Fig. 9 depicts the optimal investment strategy for γ = 6 and for one possible random scenario. The Figure shows the pattern of asset weights just described. The purpose of the 'equities' fund is to hedge human capital and to benefit from the equity premium in particular. The purpose of the 'cash' fund is first to finance the initial very high leveraged positions in equities and bonds, and then to hedge the inflation risk in labour income. An individual's labour income increases over time as a result of career progression (such as depicted in Figures 5 and 6), productivity improvements and expected inflation, and the nominal return on cash adjusts to reflect inflationary expectations.[27] The purpose of the 'bond' fund is to hedge interest rate risk, given the inverse relationship between bond – and hence annuity – prices and interest rates.

[27] Fisher (1930).

Towards the end of the investment horizon, annuity risk becomes a more important risk to hedge than inflation risk, so the weight in bonds rises and that in cash falls.[28]

5.2.4 How investment strategy is influenced by other background risks

There are other background risks that might influence the investment strategy of the pension plan. The two most important ones are housing risk and entrepreneurial risk.

A house is an asset that is lumpy and provides rental services in addition to being an investment asset. In countries with stable political systems, a house has generally been a very attractive investment in terms of long-term capital growth, although housing markets are nevertheless subject to periodic slumps (as in the UK in the early 1990s, for example). The desire to own a house can influence the age at which a pension plan begins, the amount contributed and the plan's asset allocation. Many people in countries, such as the UK, where the housing market has experienced long-term capital growth, have started to see their house as an important source of income in retirement.

Cocco (2005) and Yao and Zhang (2005) model asset allocation taking into account housing wealth. Cocco finds that younger and poorer investors prefer to invest in housing before investing in the stock market and this crowds out equity investment. Yao and Zhang examine the rent/own decision. They suggest that renting is generally, although not exclusively, associated with an individual being relatively heavily liquidity-constrained, while home ownership is generally associated with a transition to being less liquidity-constrained. They find that home owners hold a lower average proportion of equities in their total net worth holdings (i.e., bonds, equities and housing); this reflects the substitution effect of housing wealth for risky equities identified by Cocco. However, home owners hold a higher equity weighting in their financial wealth portfolio (i.e., bonds and equities). This reflects a diversification benefit: home owners can use housing wealth to hedge equity and labour-income risks.

Sun et al (2007) discuss the role of housing in asset decumulation strategies, in particular reverse mortgages (or housing equity release plans). A reverse mortgage allows an individual to consume the reversionary interest in his house while continuing to live in it. In effect, a reverse mortgage company provides a loan to the individual up to the net equity in the individual's home. This can be taken in the form of a lump sum, a lifetime income or a line of credit. Most individuals choose to take the loan in the form of a credit line. The maximum amount of loan as a proportion of net equity increases with age and is negatively related to the rate of interest. The loan plus accumulated interest is repayable only when both the individual and his spouse dies or if they sell their house. The house is then sold and the total repayment to the reverse mortgage company cannot exceed the sale proceeds. Any residual sum can be bequested. Sun et al show that, in the presence of a reverse mortgage, the optimal investment of financial wealth in equities increases. For example, at a coefficient of

[28] The models described in this sub-section all generate explicit solutions for the optimal equity weighting. They are at the very limit of complexity of the class of models providing such explicit solutions. Models more complex than these can only be solved using numerical methods. See, for example, Blake et al (2008b) for a model similar in structure to the above models, but which uses Epstein-Zin rather than power utility to allow a separation of the risk aversion parameter from the intertemporal elasticity of substitution parameter (see footnote 3): this can only be solved using numerical methods.

risk aversion of 5, the optimal weighting in equities is 55% without a reverse mortgage and 100% with.

The bottom line is that housing adds another complex dimension to lifetime portfolio allocations and ideally this should be taken into account when designing the investment strategy of a DC pension plan.

Turning now to entrepreneurial risk, Heaton and Lucas (2000) show that individuals with high and variable proprietary business income (e.g., from entrepreneurial ventures) hold less wealth in equity than similarly wealthy individuals. Such individuals are typically classed as self-employed and self-employed individuals often treat their businesses as their pension. Naturally, this should be taken into account in the investment strategies of the DC plans held by such individuals. Given that entrepreneurs typically have a high net worth, a DC plan can be tailored better to their needs than is the case for poorer people.

5.2.5 The practical implementation of the accumulation stage investment strategy.

These investment strategies are clearly very complex and their full implications are still poorly understood. They are also very information-intensive in the sense that they require constantly updated information about factors such as labour income, human capital and housing wealth. They are therefore very difficult to implement and one has to consider simpler strategies that are easier to implement.

Blake et al (2001) consider some simplified investment strategies that either approximate the optimal dynamic asset allocation (given in (31)-(33)) or protect the downside risk from investing in equities and hence increase the likelihood of achieving the goal of an adequate targeted pension in retirement. These are:

- *Deterministic lifestyling.* This strategy begins with 100% equity weighting and then linearly switches into bonds or cash in the 5 or 10 years prior to retirement.[29] The intention is to reduce the impact of a large fall in equity returns and hence fund value in the period leading up to retirement.[30] [31] If the intention is to purchase an annuity on the retirement date, the strategy will switch into 100% bonds by the retirement date. If, as is permissible in some jurisdictions such as the UK where 25% of the accumulated pension fund can taken as a tax-free lump sum, the strategy will switch 75% into bonds and 25% into cash by the retirement date. The strategy could be modified to replicate a stochastic lifestyling strategy.[32]
- *Threshold* (or *funded status* or *return banking*) strategy. This is 100% invested in equities if the fund is below a lower threshold and 100% invested in the bonds if the fund is above an upper threshold, with linear switching in between these thresholds. The thresholds are set in relation to the fund size needed to

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[29] A variation on this is a target-date fund (TDF). This automatically performs the lifestyling adjustments to the portfolio internally, so if a plan member is planning to retire in 2020, for example, he simply buys the 2020 TDF (Bodie and Treussard (2007)).

[30] The strategy is also justified in the presence of mean reversion (e.g., Samuelson (1989, 1991, 1992)).

[31] Poterba et al (2006) show that approximately the same outcome as a deterministic lifestyling strategy can be achieved with an age-independent asset allocation strategy that sets the equity weight of the portfolio equal to the average equity weight in the deterministic lifestyling strategy.

[32] Blake et al (2008, Fig. 3.5) consider this possibility in the case of two assets, equities and cash. One particular stochastic lifestyling strategy might be the mean profile from 10,000 monte carlo simulations.

deliver the target DC pension, such as a lower threshold of 20% and an upper threshold of 80%. The idea is to invest in risky assets when the fund is doing badly but to lock in returns and switch to lower risk assets when the fund is doing well.

- *Portfolio insurance*. This is the mirror image of the threshold strategy and involves buying more equities according to pre-set rules when equities are performing well and selling equities and buying bonds when equities are declining.

Blake et al (2001) conclude that the investment strategy is a critical ingredient of the pension plan, and involves a complex set of trade-offs between contributions, asset allocation, and asset risk. Conservative investment strategies will lead either to low pensions or require high compensating contribution rates. In contrast, a heavy equity component to the asset allocation will raise both the expected return on the portfolio and its risk: the first factor will have the effect of lowering the average required contribution rate, while the second will raise the *short-fall risk* (of ending up with a pension below the target pension), unless more conservative investment strategies are adopted as the retirement date approaches or the plan member is prepared to work longer or make additional contributions in the period just before retirement in the case where a shortfall is likely to emerge. These trade-offs are not well explained to plan members and given the very high degree of risk aversion reported by most of them, they will typically choose conservative investment strategies unsuited to a long-term investment horizon. However, most current plan providers will be unconcerned by this, because they have no contractual obligation to deliver any particular fund size on the retirement date.

5.3 The retirement decision and the option to retire

For many people, the decision to retire is not made by them but by their employer, and this typically happens at the company's normal retirement age. Increasingly, however, and more so as both age discrimination legislation and DC plans become more widespread, individuals have more choice over when to retire. The retirement decision can be quite complex and can depend on such factors as:

- The accumulated amount of DC wealth and the size of the pension annuity it will purchase
- Other pension wealth, especially social security wealth
- Other wealth, especially housing and financial wealth
- The employment status of the member, e.g., self-employed people tend to retire later than employees, in some cases because they enjoy work, while others cannot afford to retire because their accumulated pension is inadequate and their business does not have saleable assets (Sainsbury et al (2006))
- The health status of the member: this might either advance annuitisation in the case of very ill health or delay annuitisation in order to have cash to pay medical expenses
- The member's partner's retirement, financial and health statuses.

One way to examine the retirement decision is suggested by Stock and Wise (1990). They model the work-retirement decision in terms of the option value of continued work or equivalently the option to retire at a later date. An individual decides to retire when the expected value of continuing to work falls below the expected value of retiring. This means that a person will continue working so long as the expected utility of doing so exceeds the expected utility of retiring immediately.

Formally, if the individual retires at age τ which is greater than the current age *t*, then the discounted value of his utility over his remaining life is:

$$(34) \qquad V_t(\tau) = \sum_{s=t}^{\tau-1} \delta(s-t) U_w(L_s) + \sum_{s=\tau}^{\infty} \delta(s-t) U_r(P_s(\tau))$$

where $U_w(L_s)$ is the utility from labour income, L_s, at age *s*, $U_r(P_s(\tau))$ is the utility from the pension, $P_s(\tau)$, at age *s* (which in general depends on the retirement age, τ) and $\delta(s-t)$ is the discount factor for period $s-t$, adjusted for the individual's survival probability between *t* and $s-t$.

The expected gain, in year *t* from postponing retirement to year τ is:

$$(35) \qquad E_t G_t(\tau) = E_t V_t(\tau) - E_t V_t(t)$$

Suppose τ^* is the optimal retirement date in the sense that:

$$(36) \qquad \tau^* = arg\,max\left(E_t V_t(\tau)\right)$$

The individual therefore retires at date τ^*, since:

$$(37) \qquad \begin{cases} E_t G_t(\tau) = E_t V_t(\tau) - E_t V_t(t) > 0 & for\, \tau < \tau^* \\ E_t G_t(\tau) = E_t V_t(\tau) - E_t V_t(t) < 0 & for\, \tau \geq \tau^* \end{cases}$$

that is, the gain from postponing retirement switches from positive to negative at date τ^*.

5.4 The decumulation stage

Assuming the member lives that long, the point will eventually come when he will want to begin spending the accumulated pension fund. For most people, and especially those on low incomes, the decision to begin drawing an income from the fund coincides with the decision to retire. However, the retirement and drawdown decisions need not always coincide. Some people, for example, choose to draw an income from the pension fund before actually retiring.

An important decision that every plan member has to make is the form in which the income is drawn: should the member keep the pension fund invested in return-generating assets and draw an income from the fund (this is known as income drawdown or systematic withdrawal) or should the pension fund assets be sold and the proceeds used to purchase a life annuity? In some jurisdictions (e.g., the US, Germany, Italy, Australia and Japan), plan members are free to select whatever choice suits them. In others (e.g., the UK and Sweden), there is a legal requirement to purchase a life annuity by a certain age (e.g., 75 in the case of the UK). Plan members therefore have an option to annuitise some or all of their pension wealth, either at any age or before a legally set age.

5.4.1 The value of annuitisation

There are good theoretical reasons for individuals to eventually annuitise all their pension wealth and, indeed, their entire financial wealth. Annuitisation means that individuals are fully protected from outliving their resources (Yaari (1965)). This is an essential feature of a proper pension plan, namely a plan to provide retirement income security for however long the plan member lives (Bodie (1990)). Consequently, we would argue that unless a pension plan requires the member to purchase an annuity with the accumulated assets at some stage in the life of the plan, then it is not a pension plan in the true sense of the term, but merely an asset accumulation or long-term savings plan.

An annuity can be a valuable investment asset, especially when it is purchased at higher ages. Consider the following annuity factor, the expected present value of $1 payable each year for as long as the member lives:

$$(38) \qquad \ddot{a}_t = (1+\lambda)\sum_{s=1}^{\infty}\left(\prod_{u=t}^{t+s} p_u\right)(1+R_f)^{-s}$$

where p_u is the one-year survival probability at age u (implying that $q_u = 1 - p_u$ is the one-year mortality rate at age u), and λ is the expense loading. The annual payment on an annuity is found by dividing (38) into the value of the pension fund. An annuity is an asset with both an age-dependent and survival-dependent return. Each surviving annuitant gets a return at age u that exceeds the risk-free rate by a survival credit (q_u). This is equal to the percentage of the population of a given age that is expected to die within the next year. We can regard the survival credit as a bonus paid to those who survive by those who die. The survival credit increases with age because the survival probability declines with age. To illustrate, the one-year survival credit for a 65-year old UK male pensioner is 1.2%,[33] but the survival credit for an 85-year old UK male is 12.1% (see Fig. 10).

Nonetheless, the original Yaari argument that one should eventually annuitise all one's financial wealth depends on certain assumptions, and some of these are quite severe. Amongst these are the assumptions that the only source of risk is longevity risk[34] (i.e., the risk of running out of resources before dying), that annuities are fairly priced (i.e., $\lambda = 0$) and that the individual has no bequest motive. Fortunately, Davidoff et al (2005) show that Yaari's recommendation would hold under much less restrictive assumptions than he assumed. They show that it is optimal for an individual to eventually annuitise all financial wealth if there is no bequest motive, if the return on the annuity exceeds other assets, such as equities, and if the market is complete in the sense that all future risks can be completely hedged using currently available assets. And, when there is a bequest motive or where the market is not complete, partial annuitisation becomes optimal at some stage.

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[33] Based on the PMA92 mortality table for life office pension annuitants produced by the UK Institute of Actuaries.
[34] There is no inflation or interest rate risk, since Yaari assumed a single riskless asset.

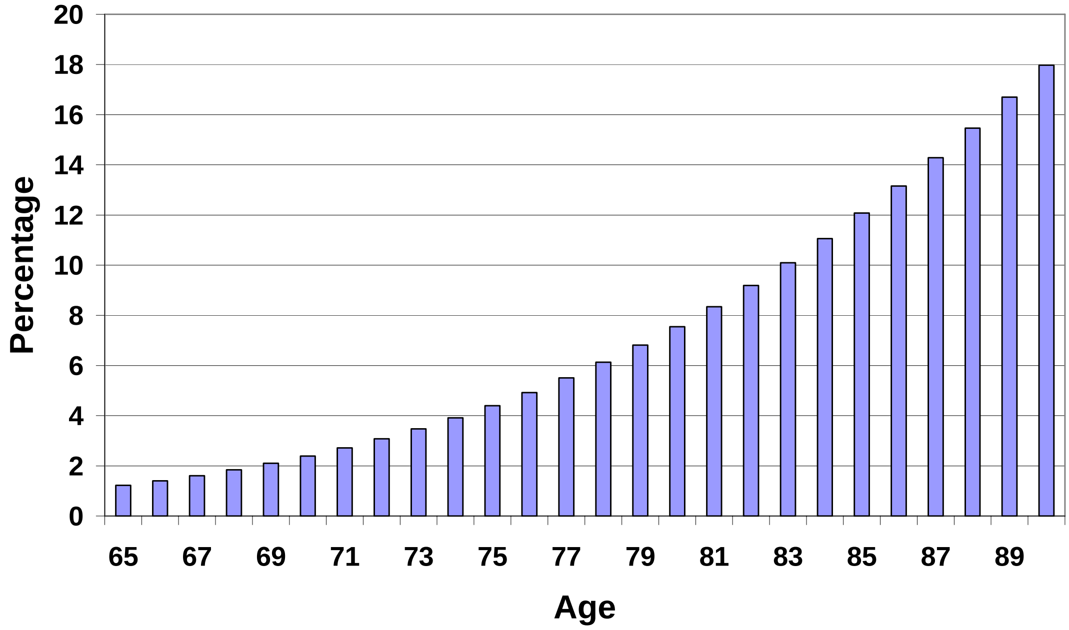

Fig. 10 Annual survival credits for UK males from age 65

Thus, despite the intrinsic value of an annuity, it might not be optimal to annuitise *all* the accrued pension fund *at a single point in time* such as the retirement date. This is in part because, by annuitising all pension wealth on, say, the retirement date, the plan member is converting into an investment that is linked to the return on bonds[35] and hence foregoes the equity premium available by keeping the accumulated fund invested in equities.

This consideration suggests that we need to treat the decision about *when* to annuitise separately from the decision about *how much* to annuitise. Clearly, the possibility of delaying annuitisation is only open to those with alternative resources to live off in the meantime.

5.4.2 The option to annuitise: when?

The decision about when to annuitise can be thought of as an option and will depend on the survival credit, the degree of risk aversion, annuity income risk, and the fund size.

One of the earliest studies analysing this option is Milevsky (1998). He proposed a simple rule for determining the optimal time to annuitise: in the absence of a bequest motive, it is optimal to switch fully into annuities when the survival credit just begins to exceed the equity premium.[36] From Fig. 10, this occurs at age 79 when using the long-run historical risk premium of 7.43%. However, Milevsky ignored risk aversion and his decision rule is not optimal when the prospective annuitant is risk-averse. By

[35] In fact, it is equal to the return on bonds plus the survival credit if the individual survives another year, or equal to zero if the individual dies during the year,

[36] This is equivalent to saying that it is optimal to purchase an annuity when the return on an annuity (which equals the risk-free rate plus the survival credit) exceeds the return on equities (which equals the risk-free rate plus the equity premium).

contrast, Milevsky and Young (2006) do take account of risk aversion and show that higher levels of risk aversion lead to lower annuitisation ages.

Further, the optimal annuitisation decision is not once and for all, but gradual (Milevsky and Young (2006) and Horneff et al (2006a,b)). This is because there is a tradeoff between the illiquidity of annuities and the longevity risk insurance they provide. Although the longevity risk insurance from annuities is valuable, the purchase decision is irreversible, so that annuities are a very illiquid asset. In option terminology, the illiquidity of annuities creates a value for the option to delay annuitisation. Milevsky and Young (2006) show that the optimal age to annuitise is when the option to delay has zero time value. They argue that the option value from waiting is valuable at younger ages and this explains why gradual annuitisation is preferable.

The annuitisation timing decision also depends on the presence of annuity income risk. In order to hedge the risk of buying an annuity at an unfavourable point in the interest rate cycle when interest rates are low and hence being locked into a low annuity amount, Horneff et al (2006a) show that it is optimal to spread the purchases over time, a strategy known as phased annuity purchases. Their analysis is broadly similar to Cairns et al (2006a), but instead of switching from cash and equities to bonds over the accumulation stage (in order to hedge the annuity income risk) as in Cairns et al., Horneff et al (2006a) recommend a strategy that switches from equities to annuities gradually over the entire life of the plan. The switch from equities is justified by the decline in human capital, while the switch into annuities is justified by the increase in the survival credit, i.e., the increase in value of the longevity risk insurance. Bonds are also held in the optimal portfolio, but mainly to meet a bequest motive, in contrast with their role in Cairns et al (2006a) which is to hedge annuity income risk. Horneff et al (2006a) show that it is optimal to begin to annuitise from as early as age 20. The rising survival credit first crowds out bonds (at around age 50) and eventually equities (by age 79): see Fig 11.

Finally, the annuitisation timing decision depends on the evolution over time of the fund size, i.e., it is path-dependent (Blake et al (2003)). Figure 12 shows some possible outcomes from an income drawdown (or systematic withdrawal) programme at selected levels of relative risk aversion (γ), beginning with an initial fund size of £100,000; shown besides the γ value is the associated optimal asset allocation for the pension fund prior to annuitisation. In each graph, the dots show how the plan member's fund value would change over time if he had opted at age 65 for a life annuity. This gives a useful reference point for comparing the fund size under a drawdown programme at different ages. The dashed lines show the stochastic trajectories of the residual fund for a drawdown programme under two particular realisations of asset returns.

We can also observe from these graphs that, for any given age and γ, annuitisation will either:

- not be optimal for any fund size
- be optimal for all fund sizes or
- be optimal for low fund sizes but not for fund sizes above some threshold.[37]

[37] The reason why it is optimal to annuitise when the fund size has become very low (say as a result of poor investment performance) is because a) the fund is unlikely to recover to its previous size even

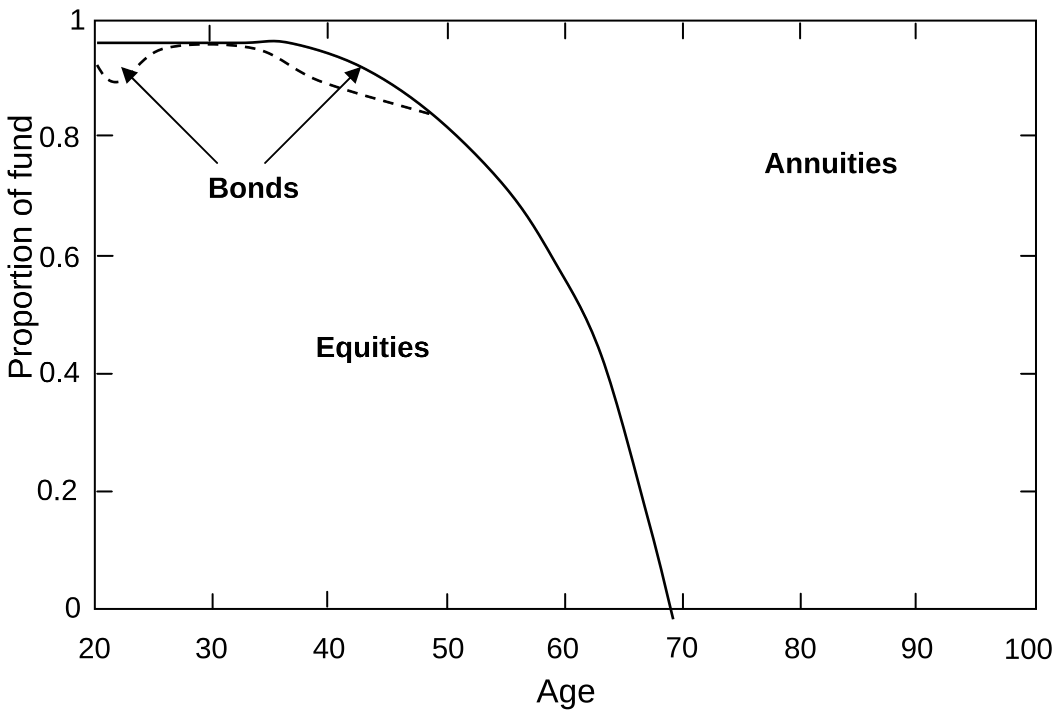

Fig. 11 The optimal asset allocation with annuities

Thus with γ = 1.58 and a drawdown programme invested 75% in equities, we can see that annuitisation is likely to occur some time between the ages of 72 (if equities perform poorly) and 80 (if equities perform moderately well). However, if equities perform sufficiently well then the fund-age trajectory will lie above the shaded region and annuitisation might only take place when it is compulsory to do so (which in the case of Fig. 12 is assumed to be at age 85). In the next plot where γ = 3.15 and the drawdown programme is invested 50% in equities, the shaded annuitisation 'hill' is somewhat lower, implying that some of the stochastic trajectories of W_t will avoid hitting the hill (and so avoid annuitisation) at ages below 85. On the other hand, if W_t is going to hit the hill it, will probably do so within the first 3 or 4 years: this case is more likely given that an income must be drawn from the fund to pay for retirement consumption.

We can infer from these observations that in some (i.e., low γ) cases, the option to delay annuitisation will not add much value (the plan member will choose to annuitise at around age 80 regardless). However, in other (high γ) cases, the shape and height of the annuitisation hill are such that many stochastic fund-age trajectories cross over the hill without hitting it, and this suggests that the option to delay annuitisation is a valuable feature.

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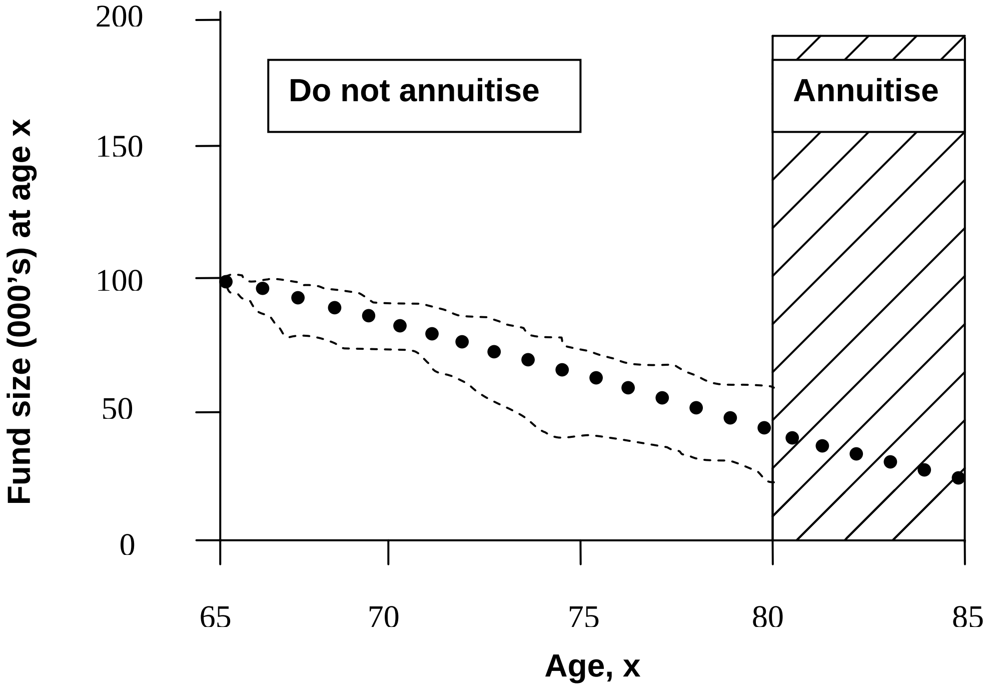
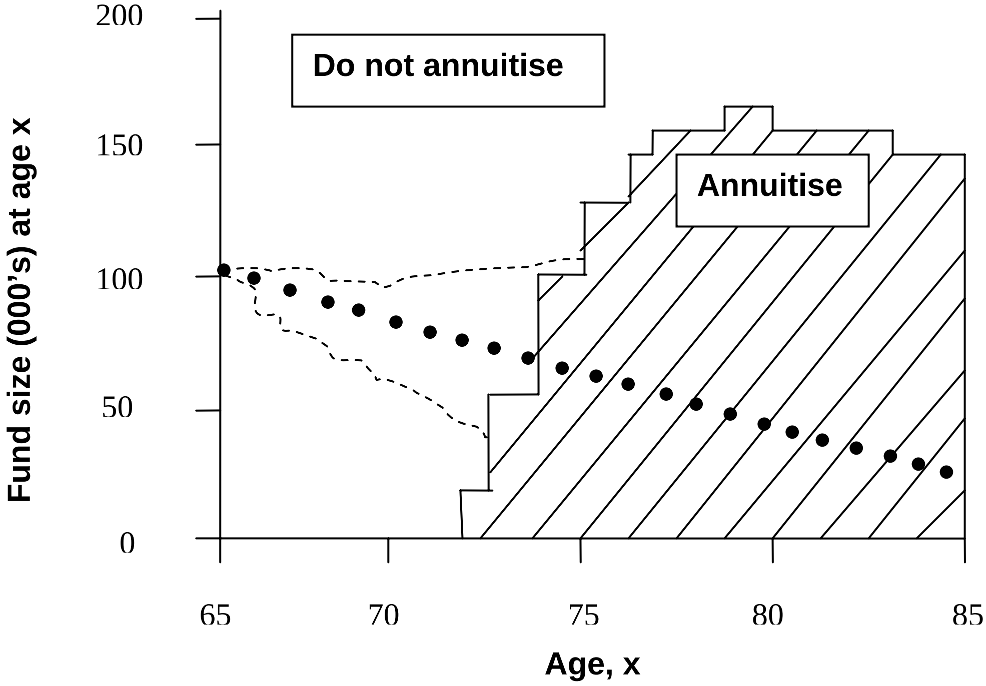
with good subsequent investment performance since an income still has to be drawn from the fund to finance consumption, b) the bequest value of the fund is low and c) survival credits begin to be earned Note, too, that the annuitisation decision is another application of dynamic programming. The result is also path-dependent since it depends on the actual realisation of the fund size over time.

γ = 0.25: 100% equities



γ = 1.58: 75% equities



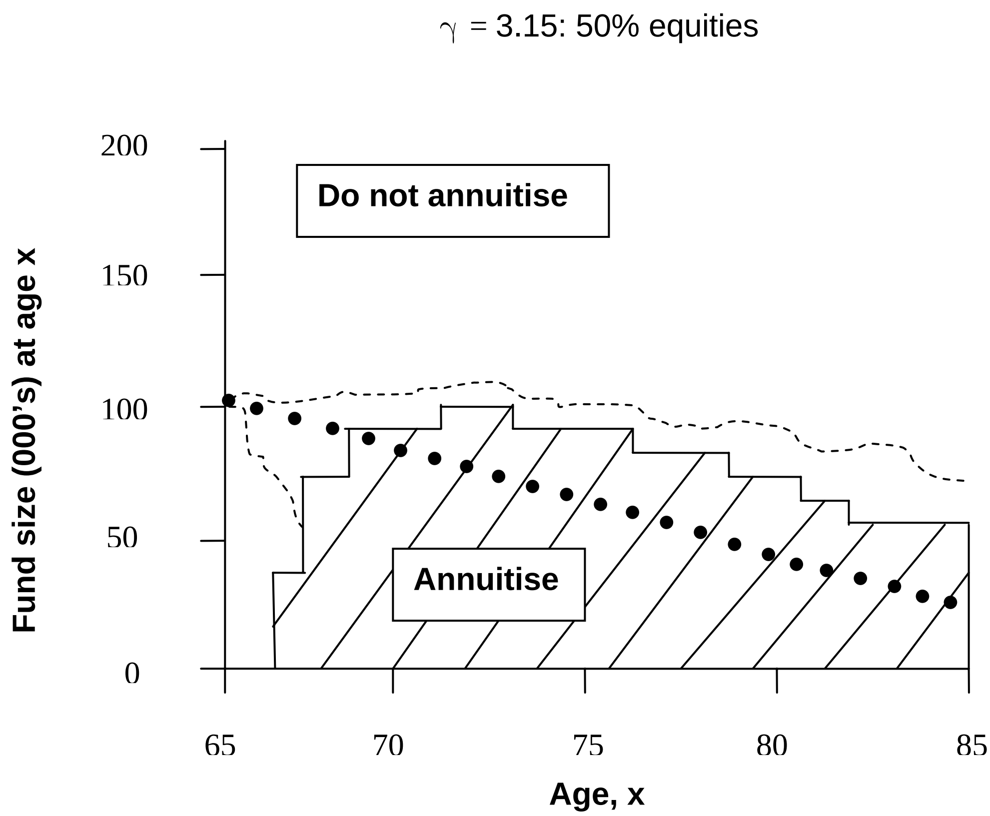


Figure 12 Relationship between the annuitisation decision and the plan member's age and fund size
(*Source*: Blake et al. (2003, Fig. 6))

It is also interesting to note that at very low levels of γ, the optimal annuitisation age of 80 is close to the age we would get (namely, 79) by applying Milevsky's (1998) rule, which specifies that we switch at the point where the survival credit equals the equity premium. This should not be surprising as the analysis in Blake et al (2003) shows that the Milevsky rule matches the optimal strategy presented in Fig. 12 only for a plan member who is close to risk neutral. Their more general analysis demonstrates that the optimal annuitisation decision is much more complex than the Milevsky rule suggests. Their analysis also tends to confirm Milevsky and Young (2006)'s finding that the higher the degree of risk aversion, the lower the age of annuitisation.

Blake et al (2003) also calculate that the cost of mandatory annuitisation at age 75 (the maximim age for purchasing an annuity in the UK, rather than at the optimal age) turns out to lie between 0% and 15% of the fund value depending on the level of risk aversion, being 15% for a risk-neutral plan member. Horneff et al (2006b) compare the case where the retiree is restricted to buying annuities only once against a strategy of gradual annuitisation: they also show that mandatory annuitisation reduces both welfare and, paradoxically, the demand for annuities.

5.4.3 The option to annuitise: how much?

There is also the option of *how much* to annuitise. An examination of recent literature suggests that the optimal degree of annuitisation is reduced if:

- state pensions are high, since these crowd out private annuitisation (Bernheim (1991))
- risk pooling within the family is efficient, especially if adverse selection and the transactions costs of entering the formal annuities market are high (Kotlikoff and Spivak (1981)); Brown and Poterba (2000b) show that married couples behave as a two-person annuity market
- risk aversion is low, since such individuals prefer equity investments (Milevsky and Young (2002))
- the equity premium is sufficiently high (Horneff et al (2007))
- investment volatility is low (Milevsky and Young (2006))
- the member is in poor health (Milevsky and Young (2002)); in such a case, an impaired life annuity will be optimal
- the member is male rather than female, given their shorter life expectancy (Milevsky and Young (2006)), and
- there is a bequest motive.

The impact of the bequest motive is also quite complicated. For example, Kotlikoff and Summers (1981) estimated that only 20% of total wealth accumulated in the US was accumulated during an individual's life as part of their lifecycle financial planning, implying that the remaining 80% was due to inheritance. The motives for intentional bequests can also vary. For example, Abel and Warshawsky (1988) found evidence of an altruistic bequest motive which they called the 'joy of giving'. On the other hand, Bernheim et al (1985) found that bequests could be used strategically in order to influence the actions of potential beneficiaries. Bequests can also be accidental because of uncertainty over the timing of death, and, in fact, Hurd (1989) found that most bequests were indeed accidental. Whatever the reason for bequests, Bernheim (1991) found that a bequest motive reduced the demand for annuities, and Horneff et al (2006a) found that it also delayed the optimal time to start buying annuities.

5.3.4 Optimal retirement-income programmes

It is clear from the above analysis that the options of when and how much to annuitise make the optimal decumulation investment strategy, like the optimal decumulation investment strategy, both highly complex and very information-intensive. At the same time, many people are unlikely to be in a position to place much value on these options, because they are unlikely to have alternative resources to live on and so cannot afford to delay annuitisation once they retire. Such people might nevertheless still value the possibility of making a bequest.

What type of annuity or drawdown programme should plan members choose? The answer depends on their desired income and hence consumption profile in retirement, as shown in Fig. 5. We also saw from Table 7 above that most individuals prefer an upward sloping income and consumption profile. Annuity providers have responded to this declaration of preferences by introducing various types of *investment-linked* *retirement-income programmes* (ILRIPs), the principal examples being income drawdown and investment-linked annuities with a substantial equity component in order to benefit from the equity premium. Individuals preferring a flat profile in real terms can achieve this using an index-linked or real annuity or drawdown programme. Those preferring a falling profile can get this using a nominal annuity or drawdown programme that generates declining real income over time. Both inflation-linked annuities and investment-linked (or variable) annuities provide an important hedge when there is inflation risk and time-varying risk premia, respectively (Koijen et al (2006)).

Blake et al (2003) investigated the following distribution programmes for a male plan member retiring at age 65 and having some investment flexibility until the age of 75, at which age, assuming he lives that long, he must buy an index-linked life annuity with the residual fund. With the exception of the first programme listed below, each programme comes in two variations: a) an income drawdown variation, in which the residual fund is paid as a *bequest* to the plan member's estate if he dies before age 75, and b) an annuity variation, in which the residual fund reverts to the insurer, in return for which the insurer agrees to pay a *survival credit* at the start of each year while the plan member is still alive:

- *Programme 1 - Purchased life annuity* (PLA): The plan member transfers his pension fund immediately on retirement at age 65 to the insurer in return for an index-linked pension. No bequest is payable at the time of death of the plan member. Instead a survival credit is implicitly payable throughout the duration of the policy. This is the benchmark programme against which all the ILRIPs listed below are compared.
- *Programme 2 - Fixed income programme* (FIX) with a life annuity purchased at age 75: In this case, the plan member transfers his retirement fund to a managed fund (which invests in a mixture of equities and bonds) when he retires at age 65. He then withdraws a fixed income each year equal to that which he would have obtained had he purchased an annuity at age 65, i.e., $W_{65}/\ddot{a}_{65}$ (if there are sufficient monies in his fund). At age 75, assuming he lives that long, he uses whatever fund remains to purchase a life annuity. There is a possibility that the fund will be exhausted before 75 (and, in the case of a 100% equity investment, there is something like a 10% chance that this will happen).[38]
- *Programme 3 - Flexible income programme* (FLX) with a life annuity purchased at age 75: In this case it is not possible to run out of money before age 75, because if the fund falls in value, the income received has to fall in tandem (i.e., at age *t* will equal $W_t/\ddot{a}_t$). The outcome will be similar to that of the flexible unit-linked programme described below, and identical in the case where a survival credit is payable. We consider four cases with different levels of equity exposure in the managed fund: 25%, 50%, 75% and 100%.
- *Programme 4 - Flexible income programme with a deferred annuity* (DEF) purchased at retirement age and payable at age 75: In this case, the plan member purchases a deferred annuity at age 65 which will provide an income from age 75 equal to that which would be payable at that age from an immediate annuity bought at age 65. He invests the remaining monies at age

[38] As discussed above, high returns can never fully compensate for poor returns if the fund also has to pay a fixed income stream, regardless of realised investment performance. Programme 2 is therefore not a genuine pension programme, but is included for completeness.

65 in a managed fund. He then draws an income from the fund on the same basis as the flexible income programme above up to age 75 when the deferred annuity comes into payment. On death before age 75, the value of the deferred annuity policy is lost. Other things equal, it is cheaper to purchase at age 65 a deferred annuity that comes into payment at age 75 than to wait to purchase the annuity at age 75;[39] this is because there is some chance that the purchaser will not live long enough to receive the annuity payments and this is reflected in the deferred annuity price.

- *Programme 5 - Unit-linked programme* (UNI) with a life annuity purchased at age 75: In this case, the plan member uses his retirement fund to purchase a fixed number of units in a managed fund at age 65. The number of units received will depend on the forecasts for mortality made at age 65. Each year a number of units are sold and the plan member's income will change in line with changes in the price of these units. At age 75, assuming he lives that long, he uses the residual fund to purchase a life annuity.
- *Programme 6 - Collared income programme* (COL) with a life annuity purchased at age 75: This programme is similar to the flexible income programme, but involves a smoothing out of investment returns. Instead of investing solely in a managed portfolio, the fund invests in a mixed portfolio of equities, put and call options[40] with the aim of achieving significant protection against downside equity risk. For each equity unit held, the portfolio is long one at-the-money put option and short one call option. The strike price of the call option is chosen so that the prices of the put and call options are equal. This means that the net cost of the resulting *collar* is zero. As a result, we have 100% participation in equity returns subject to the cap and floor. This is one way of selling some of the upside potential to pay for downside protection. The resulting smoothing of investment returns is similar in some respects to a with-profits policy although in the present case the smoothing method is much more explicit.
- *Programme 7 - Floored income programme* (FLR) with a life annuity purchased at age 75: Like the collared income programme, this programme involves foregoing some upside potential to pay for downside protection. The plan member is guaranteed to get a minimum return of zero (i.e., holds an implicit at-the-money put option), and pays for this by selling off a proportion of the equity performance above 0%. He will get some proportion (say, k) of the rise in the value of equities, with the difference of (1- k) being used to 'pay for' the put. In effect, a fraction (1- k) of an at-the-money call option is sold to pay for the put option. This annual return structure can also be achieved in a more simple way by investing in cash plus k at-the-money call options. This programme is also sometimes known as a participating-equity or guaranteed-equity programme.

Blake et al (2003) use stochastic simulation to quantify the distribution of pension outcomes from these ILRIPs. The ILRIPs are then ranked assuming the plan member has a negative exponential utility function:

$$U\left(P(t),D(t)\right)=1-exp\left(-\bar{\gamma}\left[P(t)-P_0+\theta D(t)\right]\right) \tag{39}$$

[39] This might not be the case in the presence of longevity risk, however (Blake et al (2008)).
[40] Put (call) options give the right but not the obligation to sell (buy) the equities at a predetermined price (the strike price) on the expiry date of the options.

where $\bar{\gamma}$ is the *coefficient of absolute risk aversion*:

$$(40) \qquad \bar{\gamma} = -\frac{U''(.)}{U'(.)}$$

In (39), *P*(*t*) is the pension at time *t* (and is payable so long as the plan member is still alive), *D*(*t*) is only non-zero if a bequest is payable at time *t*, θ measures the relative preference for death benefits (i.e., the *bequest intensity*), and $P_0 = W_{65} / \ddot{a}_{65}$ is the *benchmark* pension provided by the PLA. There is a different utility function for each age *t* = 65, 66, …, 75. At *t* = 75, assuming the individual is still alive, he will use the residual pension fund to buy a life annuity. We will denote by *V*, the discounted sum of all the utility functions between *t* = 65 and *t* = 75. *V* is known as the value function.

The properties of the value functions for the different ILRIPs for an investor with $\bar{\gamma}$ = 0.0001 (which corresponds to a relatively low degree of risk aversion) and θ = 1 are presented in Table 8 (programmes allowing for bequests are denoted A, while those paying survival credits are denoted B). The values in the table were determined by carrying out 2000 independent simulations of the equity return process, calibrated to UK equity returns over the last half century. For each simulation, the levels of pension and death benefit were calculated. Each of these 2000 investment scenarios was then divided into 45 mortality scenarios corresponding to the death of the policy holder at ages last birthday of 65, 66, ...,109: we assume that no investor survives beyond age 110 and that each mortality scenario is independent of the investment scenario. Each of these 90,000 scenarios has its own value *V* and we can infer the distribution of *V* from the simulated 'sample' of *V* values. The Table shows three points on the distribution, namely the mean utility level and the utility levels below which 20% and 50%, respectively, of the simulated utility levels fall.

On the basis that we would recommend the policy with the highest expected value function (or discounted utility), we would choose Programme 3B (with 100% equities) or Programme 5B. These are the flexible income and unit-linked annuities paying survival credits. For the particular plan member considered, a high level of equity investment is valued, but the possibility of making a bequest is not. An investor with a higher value of $\bar{\gamma}$ would choose a lower equity weighting, whereas an investor with a higher value of θ would choose an income drawdown programme involving a bequest.

The approach set out here is an invaluable aid for helping DC pension plan members select the right retirement product for them, once the desired income and consumption profile in retirement is known. A highly complex set of choices can be reduced to just two: finding the plan member's risk aversion parameter ($\bar{\gamma}$) and his bequest intensity (θ).

Table 8 Properties of the value functions for the different ILRIPs when $\bar{\gamma}$ = 0.0001 and θ = 1						
					Percentiles	
Programme	**Name**	**Equity %**	***E*(*V*)**	***SD*(*V*)**	**20%**	**50%**
1	PLA	0	0	0	0	0
2A	FIX	100	-70	550	-435	73
3A	FLX	25	-76	165	-211	-59
3A	FLX	50	-23	279	-238	10
3A	FLX	75	9	393	-287	44
3A	FLX	100	25	495	-354	59
4A	DEF	100	22	217	-170	38
5A	UNI	100	25	493	-344	45
6A	COL	collar	-90	166	-226	-71
7A	FLR	floor	-64	213	-241	-40
2B	FIX	100	43	524	-218	0
3B	FLX	25	70	149	-29	44
3B	FLX	50	119	282	-70	74
3B	FLX	75	145	396	-126	91
3B	FLX	100	149	495	-197	96
4B	DEF	100	50	213	-118	49
5B	UNI	100	149	495	-197	96
6B	COL	collar	56	145	-40	36
7B	FLR	floor	81	205	-50	39
Source: Blake et al (2003)						

We can summarise this section as follows:

- A well-designed DC plan will look very much like a defined benefit plan, offering a promised retirement pension, but without the guarantees implicit in the DB promise. In other words, a well-designed DC plan will try to target a particular pension by generating the lump sum on the retirement date needed to deliver that pension in the form of a life annuity, although it will not be able to guarantee to deliver that target pension. This is because guarantees over long investment horizons are very expensive to secure. For example, one way of guaranteeing to deliver a target pension would be to invest in risk-free bonds for the whole investment horizon, but this would involve foregoing the equity premium and hence lead to much higher contributions.
- Surveys suggest that individuals in retirement prefer consumption profiles that rise smoothly in real terms. They do not like to experience large cuts in consumption. Contributions into the pension plan during the accumulation stage must be sufficient to generate the fund size needed to purchase the annuity that can finance this consumption profile.
- The investment strategy during the accumulation stage should take into account the plan member's degree of risk aversion, the riskiness of his labour income and hence human capital, and possibly other background risks as well. When human capital is taken into account, the weight of the portfolio in equities is higher for any given degree of risk aversion. This is because individuals, especially when they are young, 'own' a lot of human capital and very little equity capital and to compensate for this they will increase the proportion of equities held in their pension plan. Over time, as the weight of

human capital to financial capital falls, the weight of equities in the pension fund also falls and the weight in bonds rises. One investment strategy for doing this is called stochastic lifestyling.

- In practice, however, investment strategies, such as stochastic lifestyling, are expensive to implement and manage in terms of information requirements. From an implementation perspective, there is therefore a premium on simpler-to-implement strategies include deterministic lifestyling, threshold, and portfolio insurance. However, Blake et al (2008) show that deterministic lifestyling could be used to replicate a particular stochastic lifestyle strategy(such as the mean from a simulation exercise) so long as the member was prepared to accept that this strategy would not be modified over the course of the accumulation phase in the light of new information (which, of course, is one of the main benefits of stochastic lifestyling).[41]
- For many people, the decision to retire is not made by them but by their employer, and this typically happens at the company's normal retirement age. Increasingly, however, individuals have some choice (i.e., have an option) over when to retire. This choice will depend on such factors as the size of the pension annuity from the DC plan, the level of social security payments and the health status of the individual.
- Similarly, for many people, the decision to begin drawing an income from the plan is made at the same time as the decision to retire. In general, the income can be in the form of an annuity or in the form of income drawdown or systematic withdrawal (with the fund remaining invested in return-generating assets).
- Annuities are valuable, but illiquid, investments. They generate survival credits which increase with age, so long as the plan member continues to live. Eventually, the return on an annuity exceeds that on equities. The annuitisation-timing decision depends on the degree of risk aversion: higher levels of risk aversion lead to lower annuitisation ages.
- The optimal annuitisation decision is not once and for all, but gradual. This is because of the tradeoff between the illiquidity of annuities and the longevity risk insurance they provide. In order to hedge the risk of buying an annuity at an unfavourable point in the interest rate cycle, it is optimal to spread the purchases over time, a strategy known as phased annuity purchases.
- Individuals with low degrees of risk aversion might consider an investment-linked retirement-income programme, such as a unit-linked programme, where the plan member uses his retirement fund to purchase a fixed number of units in a managed fund at retirement (say at age 65). The number of units received will depend on the forecasts for mortality made at the time of retirement. Each year a number of units are sold and the plan member's income will change in line with changes in the price of these units. Eventually (say at age 75), assuming he lives that long, he uses the residual fund to purchase a life annuity. Each programme comes in two variations: a) an income drawdown variation, in which the residual fund is paid as a bequest to the plan member's estate if he dies before, say, age 75, and b) an annuity variation, in which the residual fund reverts to the insurer, in return for which the insurer agrees to pay a survival credit at the start of each year while the plan member is still alive.

[41] In the case of two assets, equities and cash, the investment strategy would look something like Fig. 8 above.

- However, for many, if not most, people, the range of choices discussed above will not be relevant, because the fund they have accumulated will not be large enough to give value to these choices. In such cases, a simplified DC plan would involve a deterministic lifestyling investment strategy during the accumulation stage and an index-linked life annuity purchased with the accumulated fund on the retirement date.

6. This is air traffic control, are you receiving me? The role of the regulator

Until now, we have assumed that the individuals involved in pension planning over their life cycle are well-informed rational economic agents who make decisions in a way that maximises their utility or welfare. Such individuals are assumed to be able to 'interpret and weigh information presented regarding options offered by employers and governments, appropriately evaluate and balance these choices, and then make an informed decision based on a weighing of the alternatives' (Mitchell and Utkus (2004b, p.3)). But in reality individual decisions are subject to a) *bounded rationality* because certain types of problems are too complex for individuals to solve on their own (Simon (1955)), b) *bounded self-control*, since individuals lack the willpower to execute their plans (Mullainathan and Thaler (2000)), and c) various behavioural biases that are discussed below.

Few would dispute the claim that there is little need for regulation when consumers are well informed and are able to exercise and enforce their rights in a competitive market place. Unfortunately, when it comes to financial matters and especially financial products extending over long periods of time, many consumers are clearly not well-informed or well-educated. In this case, there may be a role for some kind of guide or supervisor to act on behalf of members as a surrogate 'intelligent consumer'. As regards pensions, this role might be filled by pension regulators.

One key task of such a regulator is to recognise certain behavioural biases in individual decision making. In terms of pension planning, the principal ones are the contribution puzzle, the investment puzzles and the annuity puzzle.

6.1 The contribution puzzle

As we saw above, the retirement savings decision needs accurate forecasts of lifetime earnings, asset returns, interest rates, tax rates, inflation and longevity: yet very few people have the skills to produce such forecasts (Moore and Mitchell (2000), Mitchell et al (2000)). As a consequence many people experience a significant fall in living standards after they retire (Banks et al., (1998), Bernheim et al. (2001)). All this comes as no surprise to behaviouralists, i.e., social scientists working in the fields of behavioural finance.

Behaviouralists explain this inadequate preparation for retirement in terms of lack of willpower. People might want to save for retirement, but are unable to do so (Thaler and Shefrin (1981)). The same problem faces smokers or those who want to lose weight. They understand the benefits of implementing a particular plan, and might even start such one, but they are unable to sustain the plan long enough to achieve their desired goal.

To explain this behaviour, behaviouralists argue that decision making has two dimensions: a primitive or emotional dimension and an advanced or cerebral one (Weber (2004)). Correspondingly, there are two dimensions to risk: *dread risk*, the fear of a catastrophe, and *uncertainty risk*, the fear of the new or unknown. Retirement risks are low in these two dimensions: there is neither a sufficient sense of catastrophe nor enough sense of great uncertainty for most people to frighten them into preparing for retirement and overcoming their inadequate self-control.

To overcome this problem, individuals need to employ *commitment devices* that support permanent changes in behaviour (cf Laibson (1997), Laibson et al. (1998)). Two simple examples that encourage long-term savings behaviour are auto-enrolment in a pension plan[42] and payroll deduction of contributions. Another is the 'save more tomorrow' concept of Thaler and Benartzi (2004), which exploits the behavioural traits of *inertia* and *procrastination*, whereby the plan member agrees to start or increase savings on a regular basis not now but on a future significant date, such as the date of the next pay rise or the anniversary date of joining the company.

6.2 The investment puzzles

Then there are the investment puzzles: studies of real world investor behaviour show that there is little evidence that pension plan holders invest rationally, as outlined in section 5.2 above. The median US investor holds a portfolio containing just two securities, whilst amongst the richest investors, the median holding is just 15 securities, far fewer than is needed to eliminate diversifiable risk (Polkovnichenko (2003)). Relatedly, there is also excessive DC pension fund investment in the sponsor's own shares. Mitchell and Utkus (2003) found that 11 million 401(k) plan members held more than 20% of their assets in their employer's stock, with 5 million of these holding more than 60%. This is extremely risky for obvious reasons: if the employer goes bust the plan member loses not only his job, but also much of his pension fund. This was exactly what happened with Enron, for example.

Behaviouralists have put forward a number of reasons for these puzzles.

6.2.1 Lack of firm preferences

When presented with a choice of investment strategies, pension plan members appear to have relatively weak preferences for the asset portfolio they choose (Benartzi and Thaler (2002)). In an experiment in which members were given a choice between holding their own current portfolio, the portfolio of the median member of their plan, and the portfolio of the average member, 80% preferred the median to their own and many would have been happy with the average portfolio. Only 21% still preferred their own portfolio. This indicates a herding instinct in investment behaviour in which it is comforting to be at or near the average of the peer group of co-members.

These findings come as no surprise to behaviouralists who argue that many individuals do not make decisions on the basis of firm prior preferences. In many cases, preferences only become apparent at the time a decision needs to be made, and will depend on the conditions and information available at the time. Such preference

[42] This is where the individual has to actively make the decision to opt out of the pension plan, rather than what happens at present in most plans, where the individual has to make the active decision to opt in.

forming is said to be *situational*. This leads to frequent *preference reversals*: individuals, having selected their own portfolio, can find themselves in situations where they are happier with another choice.

6.2.2 Framing effects

Investment decisions are also affected by framing effects. Experiments conducted on the effect of investment menu design on investment choices made in DC pension plans show that the menu design has a bigger influence on investment choice than the actual risk and return characteristics of the investments themselves.

For example, Benartzi and Thaler (2001) conducted an experiment in which pension plan members were invited to choose an investment mix from a choice of two different funds. One group was offered a choice between a stock fund and a bond fund, a second group was offered a choice between a stock fund and a balanced fund, and a third group offered a choice between a bond fund and a balanced fund. The most common strategy for all groups was to select an equal 50:50 mix of the two funds offered. Yet the underlying asset allocation and risk characteristics of this mix was dramatically different for each group: the equity weightings for the three groups were 54%, 73% and 35%, respectively. As the number of funds offered in the experiment increased, a *1/N rule* seemed to emerge, with allocations spread equally across the number of funds offered, irrespective of the risks characteristics. Huberman and Jiang (2006) later identified a *conditional 1/N rule*, whereby allocations are spread evenly across the subset of funds selected (i.e., conditional on the subset chosen, a 1/N rule seems to operate), again irrespective of risk characteristics.

Another experiment was carried out by Benartzi and Thaler (2002) in which DC pension plan members were offered three different menus with up to four funds: A (low risk) to D (high risk). The first menu contained A, B and C; the second menu B and C; and the third menu B, C and D. Note that B and C are the same in all menus. When it came to ranking C and B, however, C was preferred to B by 29% of those offered the first menu, by 39% of those offered the second menu; and by 54% of those offered the third menu. So C was most liked when it was the middle choice and least liked when it was listed as an extreme. This suggests that plan members follow the *naïve heuristic* of picking the middle option and avoiding extremes, instead of selecting on the basis of the return and risk characteristics of the underlying investments themselves.

In an earlier study (Thaler and Benartzi (1999)), the same authors also showed that investment decisions can be affected by how information is presented. In an experiment where the information shown to pension plan members was the one-year return on US equities, the average allocation to equities was 63%. However, when plan members were given information on the less volatile 30-year return, the average allocation to equities jumped to 81%.

These experiments indicate that the investment menu choice is an *opaque frame* which pension plan members are unable to see through to observe the return and risk characteristics of the underlying investments. This suggests that they lack firm preferences about risk-expected return characteristics and are easily influenced by the framing effects of an investment menu.

6.2.3 Anchoring effects, inertia and procrastination

Investment decision making is also affected by anchoring effects (Mitchell and Utkus (2004b)). *Anchoring* is the idea that the initial conditions used to justify a decision remain important over time however irrational this decision might be. To illustrate, Table 9 shows the 2003 equity allocations of the 2.3m members of 401(k) pension plans in the US operated by the Vanguard Group as a function of their entry date into their plan. Members who first enrolled during the equity bull market in the second half of the 1990s continued to allocate 70% of their 2003 contributions to equities, whereas those who started their plans in 2003 after a three-year slump in equities only allocated 48%. It seems unlikely that the newer entrants are sufficiently more risk averse than the late 1990s entrants to explain these large differences.

This behaviour is also consistent with the significant *inertia* and *procrastination* in investment decision-making by pension plan members documented by Madrian and Shea (2001) and Choi et al. (2001), who found that fewer than 10% of Vanguard plan members altered their contribution allocations each year.

Table 9 Anchoring and adjustment:
Current (2003) equity contributions by plan entry date
(% contribution allocated to equity investments)

Year	Percentage (%)
1992	65
1993	67
1994	68
1995	66
1996	71
1997	69
1998	69
1999	70
2000	72
2001	67
2002	58
2003	48

Source: Mitchell and Utkus (2004b, Fig. 1.4)

The excessive investment in employer stock

Mitchell and Utkus (2003) also report that 11 million 401(k) plan members hold at least 20% of their fund in their own company's shares, and 5 million hold at least 60%. This clearly violates the investment principle of good risk diversification, although it is sometimes argued that employers encourage this to provide an incentive for employees to work harder.

From a behavioural viewpoint, these large concentrations in company shares are the result not only of incentive effects, but also of computational or behavioural errors. Employees appear to suffer from *risk myopia* in respect of their own company's shares. This is illustrated by a 2003 Vanguard Group survey (reported in Mitchell and Utkus (2003)), which was conducted after the collapse of Enron in which employees lost both their jobs and their pension funds which had all been invested in Enron shares. Even after this well-publicised financial disaster, two-thirds of plan members surveyed still regarded their employer's shares as no more risky than a well-diversified equity fund, despite the greater volatility of the former. This is inconsistent with good risk diversification.

Reliance on past performance

Another anomaly is that asset allocations in DC pension plans tend to be driven by past performance rather than by expected future returns and risks. For example, Benartzi (2001) examined pension investments in employer shares and also found that plan members concentrated on returns and ignored volatility. In particular, they found that plan members forecast returns by extrapolating their company's shares' historic performance. Good past performance led to the pension fund being overweight in the employer's shares and vice versa. Comparable findings were obtained by a number of other studies (e.g. Choi et al. (2004), Huberman and Sengmueller (2003), Poterba et al. (2003), Purcell (2002)). Two behavioural factors have been put forward to explain this behaviour

The first is the *representativeness heuristic* identified by Tversky and Kahneman (1974). For example, if they are offered a short series of random numbers, individuals will often try to identify a pattern in these numbers. Similarly, when making decisions, people often try to impose some order or structure on the information they use.

The classic example of this is to examine the investment performance of the top-performing mutual fund manager over the last three years, say, and draw the conclusion that his pre-eminent position is due to skill, whereas an equally and usually more likely explanation is that his position is due to pure chance.

This representativeness heuristic might be caused by a framing effect. Rather than use a wide frame to assess skill versus luck, such as the population of all mutual fund managers, the individual investor might adopt a narrow frame, such as the three-year track record of a single fund manager. This leads to random outcomes being incorrectly interpreted as logical sequences.

The second is the *availability heuristic*. Confronted with a complex decision, individuals often use whatever information is readily at hand. In the example above, investors rely on past performance probably because it is freely available from newspapers and websites and is used despite the small print warning that 'past performance is no guide to future performance.'

These two heuristics might help to explain the *return chasing phenomenon* observed in mutual fund purchase decisions (Patel et al. (1991)). This is where mutual fund investors rush into funds whose recent past performance has been exceptional, irrespective of these funds' future prospects.

Prospect theory

There is also some reason to suspect that individuals do not in practice maximise expected utility. According to *prospect theory* developed by Kahneman and Tversky (1979), individuals maximise a non-linear value function as in Fig. 13. This optimisation problem differs from expected utility maximisation in two important respects. First, individuals judge how their decisions affect incremental gains and losses to their wealth, rather than how they affect their total wealth (as required by standard utility theory: see Fig. 1). In addition, individuals treat gains and losses asymmetrically: losses have a much more negative impact on welfare than the same dollar gain has on improving welfare. The *gain function* (to the right of the origin) is concave, but the *loss function* (to the left of the origin) is convex and has a much steeper slope. In experiments, Kahneman and Tversky found that the index of loss-aversion is about 2.5. This implies that a typical individual would not be willing to take part in a fair game unless the potential gain was 2.5 times the potential loss.

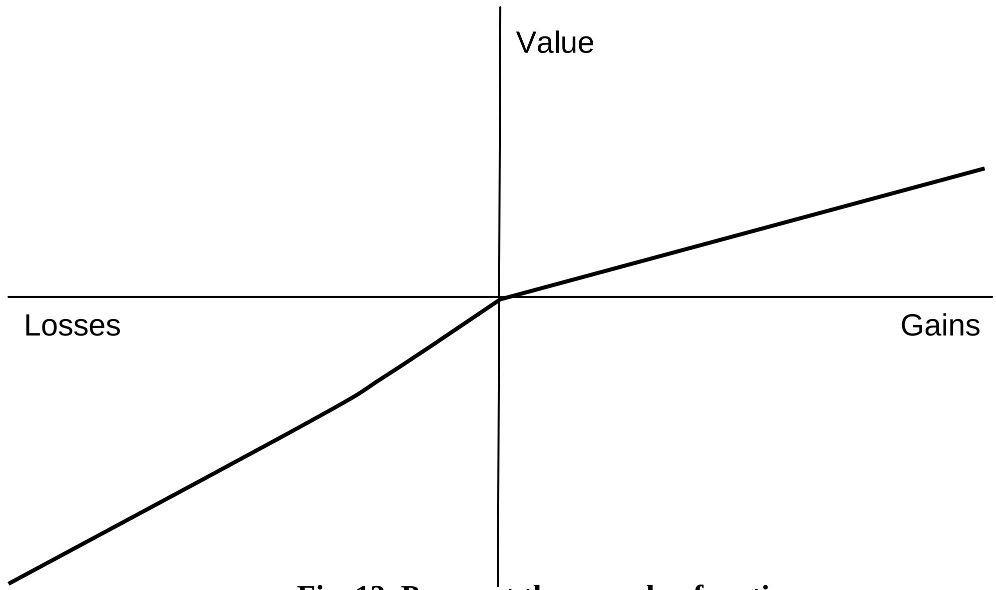


Fig. 13 Prospect theory value function

Prospect theory has powerful implications for investment behaviour. Investors will be risk averse for a realised gain and will act to lock in this gain prematurely, an effect called the *disposition effect* by Shefrin and Statman (1985).[43] When it comes to losses, a *breakeven effect* operates. Recognising they face a certain loss, many investors take on additional risk in an attempt to recover their investment and breakeven. This is particularly so in falling stock markets, where losses are perceived as temporary and another bet will enable the losses to be recovered. By contrast, rational economic behaviour predicts that realised losses should be ignored on the grounds that they are sunk costs.

Kahneman (2003) argues that prospect theory is important for understanding investment decision making in three ways: it leads to overconfidence in the domain of gains, combined with premature realisation of investment gains; it leads to a policy of loss avoidance in the domain of losses; and it leads to these features being magnified by narrow framing effects or mental accounting.

Overconfidence

A key finding of behavioural economics is the tendency for individuals to be overconfident about the future and to make excessively optimistic forecasts. Overconfidence in decision making, as a consequence of an inflated view of one's own skill and ability, is a widespread phenomenon in a wide range of spheres, especially in business and investments. At the same time, people can be much more critical of the skills and abilities of others. This overconfidence is, in part, caused by a tendency to underestimate the impact of chance in determining future outcomes and to subsequently overestimate one's degree of control over these outcomes; and the stronger the feeling of control, the more powerful the feeling of confidence.

Overconfidence might be the beneficial source of business risk-taking, but it can also induce sub-optimal behaviour in the field of investing. An illustration is excessive trading in equities. According to a study by Barber and Odean (2000), typical US brokerage account holders have a turnover rate of 75% p.a. The 5-year average return of active traders was 11.4% p.a., compared with an overall market return of 17.9% p.a, and a return on low-turnover accounts of 18.5% p.a. Further, men trade 45% more than women.

There is also evidence that rich male investors experience overconfidence and emphasise personal investment skills. In a study by de Bondt (1998), many investors showed a high degree of confidence about their stock picking ability and dismissed expected utility maximisation factors such as diversification. On a related note, Goetzmann and Kumar (2001) show that although individual investors might own portfolios containing a variety of equities, these portfolios tend to consist of securities from highly correlated sectors, and are therefore not genuinely diversified.

Loss aversion

Loss aversion explains why investors are reluctant to 'cut their losses' and keep loss-making positions in the hope that they will recover their original investment. For example, Odean (1998) reports that investors who hold on to loss-making positions underperform the market in the following year by 1 percent. He also found that

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[43] However, many investors switch from risk-averse to risk-seeking behaviour if they feel they are risking someone else's money (e.g., accumulated earnings from prior bets): this is known as the *house money effect*.

investors sold their winning positions too quickly, i.e., failed to ‘run their profits’, and subsequently underperformed the market over the next year by 2%. The net effect of these two behavioural traits was therefore 3% p.a.

Small-scale risk aversion seems to result from a tendency to assess risk in isolation rather than in a broader context (i.e., the investor is ‘thinking small’). If small-scale, better-than-fair gambles were assessed in a broader context, individuals would be more likely to accept them. Many individuals refuse to accept a coin-tossing gamble where heads wins $200 and tails looses $100. However, if the gamble is rephrased in terms of a $200 increase in the individual’s housing equity if the coin shows heads and a $100 reduction if tails, then more people are likely to take part (Rabin and Thaler (2001)).

As Benarzi and Thaler (1995) discovered, loss-averse investors can act myopically in evaluating sequences of investment opportunities, and this leads to myopic loss aversion (MLA). A feature of MLA is excessive monitoring of the investment performance of the investment programme, even by long-term investors, and evidence suggests that the more frequently returns are evaluated, the more risk averse investors will be (Gneezy and Potters (1997)). Another symptom of MLA is overinsurance against small-scale low-risk events, such as extended warranties on household appliances (Rabin and Thaler (2001)).

Benarzi and Thaler (1995) also showed that, while a MLA investor would reject a single small-scale, better-than-fair gamble such as the coin-tossing gamble of $200 winnings versus a $100 loss, he would be prepared to engage in a series of such gambles (i.e., the investor switches to ‘thinking big’), so long as each gamble in the sequence was not individually monitored. To avoid the risk that the investor withdraws from the sequence of gambles in response to early losses, a commitment device is needed. An example would be a standing order for the premiums to a personal pension plan, rather than an annual invitation to send a cheque to the plan provider. The plan provider should also report the performance of the plan’s assets to the plan member no more frequently than annually. This would help to sustain commitment and help to avoid the overconfidence that would emerge in the investor if the early sequence of gambles fortuitously showed net winnings.

Narrow framing or mental accounting

Overconfidence and loss-aversion are also exacerbated by *narrow framing* effects, also known as *mental accounting*. Mental accounting plays a key role in understanding investor attitude and response to risk. Mental accounting is the set of cognitive operations individuals seem to use to keep track of financial transactions and evaluate them (Kahneman and Tversky (1984, 2000), Thaler (1985, 1999), Barberis and Huang (2001)). One feature of mental accounting is the assignment of specific activities to specific accounts. For instance, expenditures are grouped into categories (e.g., housing, food, holiday savings etc) and spending in these categories is often limited by implicit or explicit budget constraints.

6.3 The annuity puzzle

Finally, there is the question of the annuity puzzle. Despite the benefits of annuitisation, very few people choose to annuitise their pension wealth unless the rules of their plan oblige them to do so. In countries such as the US, Germany, Australia and Japan, there is no mandatory requirement to purchase an annuity at any stage during the life of a DC plan and very few plan members voluntarily do so. In a few countries, the key example being the UK, there is a mandatory requirement to purchase an annuity by age 75 at the latest. Indeed, more than half the world's life annuities are sold in the UK (300,000 in 2005, with premiums of £8bn[44]) and most of these are level annuities that do not adjust for inflation. The global market in life annuities is currently tiny in comparison with what we would have expected it to be. This puzzle is reinforced by evidence that annuitants are more satisfied in retirement than those without annuities (Panis (2004)).

The extent of annuity aversion is shown by a recent study of the behaviour of 65,000 US soldiers made redundant in 1992 following the end of the cold war (Warner and Pletter (2001)). These soldiers were offered an early retirement package involving either an annuity or a cash lump sum. The return on the annuity ranged from 17.5% to 19.8%, compared with a return on government bonds of 7%. Fifty two percent of the officers and 92% of the ranks elected to take the lump sum over the annuity, thereby foregoing $1.7 billion in economic value.

The possible behavioural explanations for why people choose the lump sum over the annuity are:

- Overconfidence: many people underestimate how much they need to live on after retirement
- Lack of self-control: some people actually spend all their retirement savings within a few years of retirement
- The framing effect: choices can be framed in a way that causes people to overvalue the 'large' lump sum and undervalue the 'small' annuity.
- Poor financial literacy: most people are not sufficiently competent to manage the drawdown of their investments in old age (Dus, Maurer and Mitchell (2003)).

Pension plan members who do not purchase annuities leave themselves exposed to a number of risks: longevity and health risks, inflation risk and capital market risks.

6.3.1 Longevity and health risks

As we have seen, longevity risk can be eliminated by purchasing a life annuity at retirement. Nevertheless, most DC plan members, given the choice, do not choose to buy annuities with their accumulated lump sums. Similarly, in the case of DB plans in the US, most (75%) of company pension payouts now take the form of lump sum payments (McGill et al. (2005)), whereas previously they took the form of a retirement pensions. This means that increasing numbers of people are failing to hedge their own longevity risk, i.e., the risk that they will live longer than anticipated.

A number of explanations have been offered to explain this phenomenon:

- People tend to underestimate how long they will live after retirement. According to O'Brien et al (2005), British males under-estimate their life expectancy by 4.62 years, while British females underestimate theirs by 5.95 years, compared with the estimates of the UK Government Actuary's

[44] H M Treasury (2006).

Department (see Fig. 14). Similar results hold in the US (see, e.g., Drinkwater and Sondergeld (2004)).

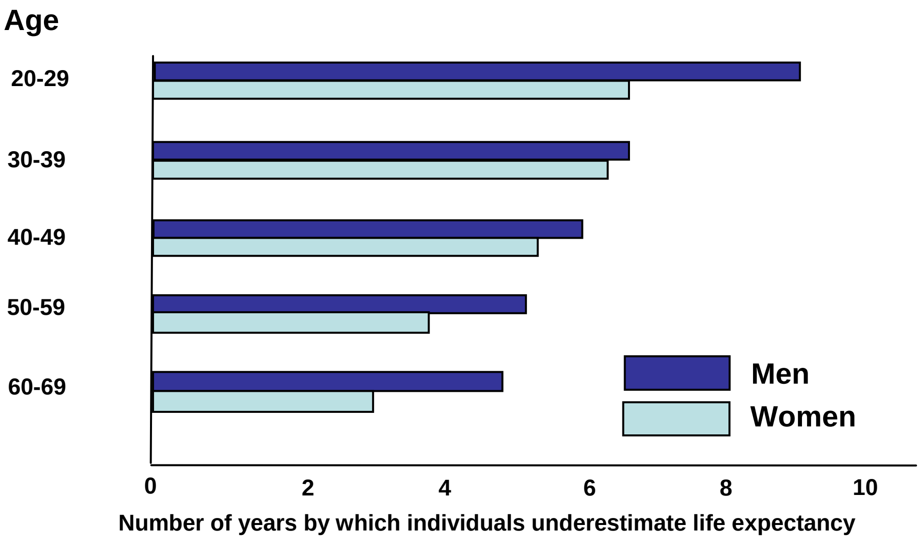

Fig. 14 Individual underestimates of life expectancy by age

(Source: O'Brian, Fenn, and Diacon (2005))

- People usually have a state pension which implies some insurance against longevity risk
- In a world of low interest rates, annuity rates are also low, so annuities appear to offer poor value for money
- The cost loading of the annuity provider reduces the return compared with a pure investment (yet the evidence indicates that the *money's worth* of annuities is high: see e.g., Mitchell et al. (1999) on US annuities and Finkelstein and Poterba (2002) on UK annuities).
- People might have a strong bequest motive. Individuals are concerned that they might die shortly after buying the annuity in which case the lump sum used to buy the annuity would no longer be available to make bequests.
- People might also be concerned about future long-term care costs. Individuals tend to retain large holdings of assets until very late in life, in contrast with the predictions of the life cycle model. De Nardi et al. (2006), using the US Assets and Health Dynamics of the Oldest Old (AHEAD) dataset, show that out-of-pocket medical expenditures rise very rapidly with age. To illustrate, average annual spending for a woman in poor health increases from $1,200 at age 70 to $19,000 at age 100. Second, health care is a luxury good with the amount spent on it more than proportionately increasing with income. For example, a 95-year-old woman in poor health at the 20th percentile of the income distribution spends $2,700 on health care, while if she is at the 80th percentile of the income distribution, she spends $16,000. There are also large differences in life expectancy across the income distribution at older ages: a 70-year-old man with poor health and a low income can expect to live only 6 more years, while a 70-year-old woman with poor health and a high income can expect to live 17 more years. De Nardi et al. develop a model that takes account of this diversity in mortality and out-of-pocket medical expenditures and show that it fits the data much better than previous studies. In particular, they are able to predict the slow rate of asset decumulation after age 70 that

occurs in the data. To address concerns about future long-term care costs, some insurers offer annuities combined with life assurance, long-term care and disability benefits.

- Adverse selection and the asymmetric information between the annuity buyer and seller. Individuals hold private information about their health status which it is hard for an annuity provider to identify. It is therefore optimal for healthy individuals to purchase annuities before the annuity provider discovers their true health status. Aware that healthy individuals are more likely to purchase annuities voluntarily than unhealthy individuals (adverse selection), the annuity provider will raise the price of annuities to protect itself. This reduces the value of annuities to average individuals and hence lowers their demand for them (Brugiavini (1993)).

6.3.2 Inflation and capital market risks

Inflation reduces the real value of investments paying fixed income returns such as level annuities, as discussed in section 5.3.4 above. Inflation risk can be hedged by purchasing index-linked annuities. However, if inflation is expected to be 3% p.a., an indexed annuity will have a starting payment that is 30% below that of a level annuity. It will take 11 years for the cash payments on the two annuities to equalise, and 19 years in total for the total payments on the indexed annuity to exceed those of the level annuity. Given the choice, few people choose the indexed over the level annuity.

An alternative inflation hedge is an investment-linked annuity, with a high weighting in equities. Equities should provide a good long-term inflation hedge. However, Brown et al. (2000a) show that equities have been a poor inflation hedge in the US, at least in the short- to medium-term. Also their returns can be very volatile over short horizons.

6.4 What should pensions regulators do?

The existence of behavioural biases suggests a possible task for those charged with looking after or regulating pension schemes: these pension regulators should aim to ensure that pension plans are designed to minimise the effects of behavioural biases.

Mitchell and Utkus (2004b) suggest that we should learn the following lessons:

1. Behavioural research challenges some of the most central assumptions of decision-making.

Contrary to the expected utility maximisation model, behavioural research suggests that workers are not rational life-cycle financial planners in respect of their pension plans. Mitchell and Utkus identify a number of reasons for this:

- self-control problems over savings, which creates a need for commitment devices
- a divergence between desire and action, which requires the default option to be appropriately designed
- weak or uncertain preferences about the basic questions of how much to save or how much risk to take, which can also be influenced by the default

- a poor understanding of risk, as evidenced by an over-emphasis on past performance, overconfidence about the future, a concentration on gains and losses, and an irrational preference for lump sums over annuities.

2. *Plan design drives participant decision*

The combination of default, framing and inertia effects means that investment and saving decisions are heavily influenced by the design of the pension plan. Similarly behaviour can be altered by merely changing the default structures. Of particular importance are the design decisions selected by the employer on automatic enrolment, automatic saving, and default investment funds. Thaler and Sunstein (2003) argue that the solution is a strategy of *paternalistic libertarianism*, in which individuals can be offered some choice, but the choices are predetermined by a paternalistic plan designer.

3. *The current design of DC plans does not encourage pension savings.*

This follows because workers are told in effect that:

- saving is optional (since joining the plan is an active decision),
- the need to increase saving is optional (again this requires an active decision) and
- risk is a bad thing rather something that is a necessary feature of a balanced investment portfolio (since the default fund is generally a low-risk fixed income fund).

4. *Current work-place financial education is inappropriate*

The current model of providing work-place information to employees assumes that workers are rational economic planners, but this is not the case. An alternative model is that desired behaviour must come about before education (Selnow (2004)). The defaults are needed to induce the 'correct' behaviour, and then education is used to explain the defaults. In other words, behavioural economics suggests a reversal in the education-behaviour causality link.

These lessons have some major implications for plan design choices:

1. *Much depends on the default choices in defined contribution plans.*

Behavioural traits such as inertia, procrastination, and lack of decision-making willpower can be used constructively to increase pension saving. This is how 'save more tomorrow' plans work: automatic enrolment of all workers, planned annual contribution increases, and default funds that constitute optimal portfolio choices, e.g., balanced portfolios with age-related switching to bonds as retirement approaches (i.e., stochastic or deterministic lifestyling). The passive decision-maker can then depend on the plan design to achieve a good pension outcome. At the same time, if they wish to, financially skilled workers can reject the defaults and make their own preferred choices. Byrne et al. (2007) conducted a survey of UK pension professionals which clearly shows that what pension plan members want to know is not what are the risk and return characteristics of the different asset classes or investment funds, but what these asset classes and investment funds will achieve.

2. *Simplified menu design in retirement plans could be very useful.*

It is clear that 'choice overload' in investment menus can have a negative impact on plan participation: what is needed is a limited menu of core choices, and, separate from the main menu, an expanded range of options for more sophisticated investors.

3. *New approaches are needed to help workers and retirees better manage company stock risk.*

The behavioural finding concerning excessive investment in the employer's equity in US 401(k) pension plans suggests a possible need to limit the level of self-investment as in the UK (where it is capped at 5%).

4. *Sensible plan design includes default choices at retirement.*

Behavioural research suggests that the framing of the annuity versus lump sum decision can be improved, and there is a good argument that the annuity should automatically be the default option in DC plans, as it is in DB plans. Account should also be taken of worker understanding of mortality and investment risks.

Further, pension regulators should insist that there are governance structures in place that ensure:

- effective targets for fund managers during the accumulation stage and for annuity providers during the decumulation stage
- the safe custody of contributions and accumulating assets
- charges are not excessive, and strike an appropriate balance between cost and efficiency

We can summarise this section as follows. The role of the regulator should be to design pension plans to minimise behavioural biases including:

- having target annuitization funds (that is, funds that target a particular pension as a proportion of final salary) as default options during the accumulation stage
- allowing flexible retirement products that take into account risk aversion, bequest motives and long-term care costs (especially in countries with large first pillars)
- better information to members concerning the various tradeoffs implicit in a DC pension plan.

7. Completing the market in longevity risk transference: A role for government?

While there is no shortage of investible assets in the accumulation stage of pension plans, there are clear limits to the capacity of insurers to provide annuities in the decumulation stage. Some commentators believe that the largest single cause of this capacity constraint is the absence of an effective means of hedging the aggregate longevity risk contained in annuities (e.g., Wadsworth (2005), Blake et al (2006)).

The problem is that aggregate longevity risk, the risk of unanticipated increases in longevity across the whole population, cannot currently be hedged. To illustrate this problem, Fig. 15 illustrates longevity risk using a survivor fan chart for English and

Welsh males who were 65 years old in 2002 (Blake et al (2008a)[45]). This shows that there is little risk before age 75, but thereafter uncertainty about the life expectancy of this increases dramatically and peaks at an age a little over 90.

Blake and Burrows (2001) proposed one possible solution to this problem, namely *longevity* (or *survivor*) *bonds* issued by the government. Longevity bonds are bonds whose coupons are not fixed over time, but fall in line with a given survivor index, which might for instance be based on the population of 65-year-olds alive on the issue date of the bond. Suppose the government issues such a bond and it is bought by an insurance company that has just sold annuities to a group of 65-year olds. The bond would provide a hedge for the annuity book, as unexpected changes in the survival rates that affect the payments on the annuity book would also affect coupon payments on the bond.

But why should the government (and ultimately taxpayers) issue longevity bonds and absorb the risks associated with mortality fluctuations? A possible justification sometimes suggested can be found in the Arrow-Lind Theorem (1970) on social risk-bearing: this shows that the associated risk premium can be reduced to zero, by dispersing an aggregate risk across the population (of taxpayers) as a whole. This would suggest that the government could therefore issue longevity bonds at a lower yield (namely, the risk-free rate) than any private corporation could. The private corporation will have many fewer shareholders than there are taxpayers, and some of the shareholders may hold large blocks of shares that constitute a significant proportion of their net worth. These shareholders will demand a risk premium, whereas the government can act as a risk-neutral player. Another possible justification lies in the government's own public health campaigns that are aimed directly at improving the mortality of the whole population, and this has important implications for annuity provision by the private sector. However, it is also arguable that the assumptions underlying the Arrow-Lind theorem do not hold in practice, and a case can be made that longevity bonds should be issued by private sector financial institutions rather than by the state (see, e.g., Dowd (2003)).[46]

Another argument, recently made by the UK Pensions Commission, is that the government could play a limited pump-priming role in the longevity bond market:

> *One possible limited role for the government may, however, be worth consideration: the absorption of the 'extreme tail' of longevity risk post-retirement, i.e., uncertainty about the mortality experience of the minority of people who live to very old ages, say, beyond 90 or beyond 95. Some industry participants have suggested that this risk has a disproportionate effect on the feasibility of private sector issuance of longevity bonds and on*

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[45] The fanchart shows the central 10% prediction interval with the heaviest shading, surrounded by the 20%, 30%, …, 90% prediction intervals with progressively lighter shading. The bounds of the 90% prediction interval are indicated by black lines for greater visibility. Estimated using 10000 monte carlo simulation trials with the stochastic mortality model of Cairns *et al* (2006b) calibrated on GAD data over the period 1982-2002.

[46] The world's first capital market transaction to hedge longevity risk did in fact take place in the private sector between investment bank JPMorgan and a UK insurance company called Lucida in February 2008. It was not, however, a longevity bond, but rather a type of longevity swap (called a q-forward, see Coughlan et al (2007)). A longevity bond is constructed from an annuity bond and a longevity swap (see Blake et al (2006)).

the prices which need to be charged for annuities. If this is the case, and if but only if the government can significantly reduce its exposure to pre-retirement longevity risk, via reform of pension ages in the state system and in public sector employee plans, a government role in absorbing this very long tail liability may be appropriate. Pensions Commission (2005, p229)

Other supporters of government-issued longevity bonds in the UK include the National Association of Pension Funds and the two largest life assurers the Prudential and Legal & General (Pensions Commission (2005, Tables B14 and B15).

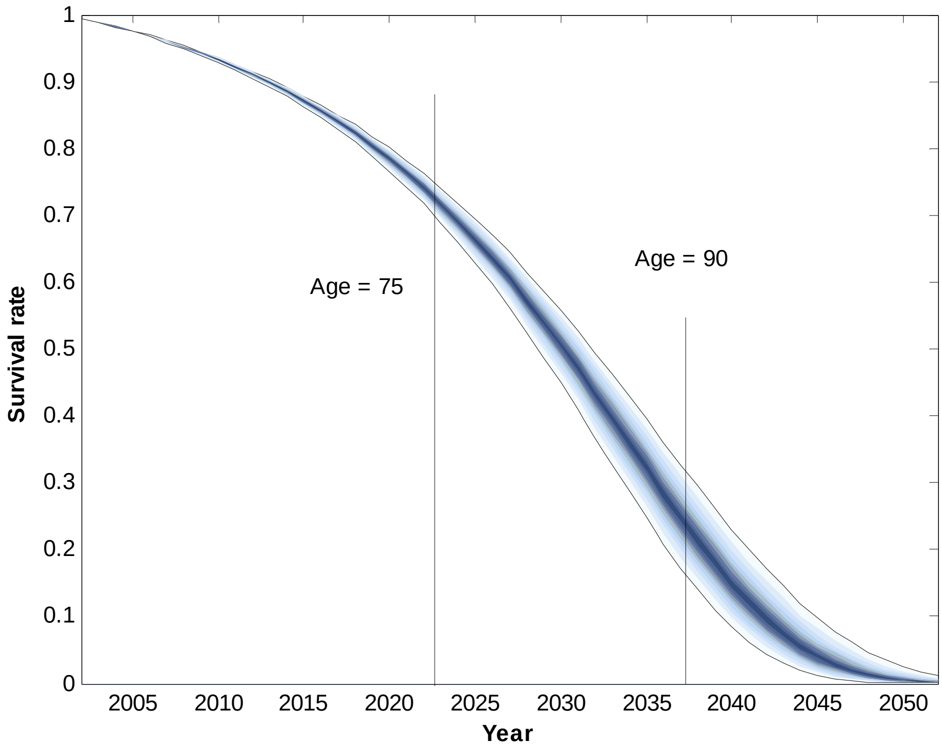

Fig. 15 Survivor fanchart for 65-year old English and Welsh males from 2002
(*Source*: Blake et al (2008a))

9. Conclusions

Two key conclusions are glaringly obvious from the above analysis. The first is that there is strong evidence that individuals cannot be regarded as 'intelligent consumers' when it comes to understanding and assessing different investment strategies for their pension plans. The second is that DC pension plans and their investment strategies are currently in a very primitive stage of their development. It is also clear that these two conclusions are related: the poor knowledge and understanding of pension plan members gives plan providers very little incentive to improve the design of their pension plans.

While the authorities are becoming aware of the poor standards of financial literacy (e.g., the UK Office of Fair Trading (1997, 1997)), it is likely to be a long, slow process to raise standards of financial literacy to the level needed both to protect DC pension plan members and to get them to fully understand how to invest their pension assets (OECD (2005), Financial Literacy and Education Commission (2006), Thoresen (2007)[47]).

However something can be done about the design of pension plans and their investment strategies. We used the analogy of designing a commercial aircraft journey to help to explain the accumulation- and decumulation-stage investment strategies. A well-designed commercial aircraft journey involves very few passenger instructions, little more than ‘please fasten your seatbelt’: all the risk management has already been undertaken by the designers. A well-designed pension plane will be similar. Like an aircraft journey, it will be designed from back to front (that is, from desired outputs to required inputs) with the goal of delivering an adequate targeted pension with a high degree of probability. Once a few key parameters about the plan member are known (the shape of the career salary profile, the desired retirement income profile, the planned retirement date, the degree of risk aversion and the bequest intensity), the pension plane provider can be left to do what is needed to get the plane safely to its destination, so long as the member believes in the benefits of the pensions journey he is making and is willing and able to maintain the required contributions schedule. There will still be risks, of course, but these will be as well understood and as well managed. Once this has happened, we will be in a position to think not of pension plans, but of pension planes, with the equivalent safety instruction to ‘fasten your seat belts’ being simply ‘just sign up’ (or even better ‘please ask for an opt-out form’).

It is the role of the regulator to ensure that all this happens by acting as an ‘intelligent consumer’ on behalf of plan members. And so well informed will the regulator be that he will be able to produce on an annual basis, Tables 10-12, the DC pensions equivalent of Tables 1-3 on the distribution of risks in DC plans.

A third conclusion is that flexibility in the design of DC pension plans is valuable only above a certain minimal fund size. Examples of flexibility include choice over accumulation-stage investment strategy, retirement date, and choice over pension annuity or drawdown programme. For poorer individuals, such choice flexibility will not be feasible. In fact, to avoid the potential moral hazard problem of individuals consuming their retirement pot too quickly and falling back on the state for support, there needs to be a minimum annuitisation fund accumulated before any investment flexibility post-retirement should be safely permitted. Members with accumulated funds that below the minimum annuitisation fund level needed to keep them off further state support should be required to purchase an index-linked life annuity with their accumulated fund.

[47] The UK government’s objectives are as follows:

- all adults in the UK to have access to high-quality generic financial advice to help them engage with their financial affairs and make effective decisions about their money;
- all children and young people to have access to a planned and coherent programme of personal finance education, so that they leave school with the skills and confidence to manage their money well; and
- a range of Government programmes that focus on improving financial capability, particularly to help those who are most vulnerable to the consequences of poor financial decisions.

The analysis in this report has been based largely on studies of DC plans in developed countries, such as the UK and US. The final conclusion is that this analysis needs to be modified for developing countries. For example, DC plans are typically mandatory, so there is no choice but to get on the plane! The authors are not experts on DC plans in developing countries, but understand that the following factors are pertinent:

- Equity markets are more volatile and less liquid than in developed countries.
- There are fewer investment alternatives than in developed countries, markets are more incomplete (e.g., annuity markets), and there are other risks that are not as severe in developed countries (e.g., currency and confiscation risks).

These factors will tend to weaken the efficaciousness of DC plans in developing countries, unless measures are taken to rectify them.

Table 10 Distribution of risk by stage of pension plan		
	Percentages	
	Risk[a]	Exposures[b]
Initial marketing	1	-
Accumulation stage	51	55
Switchover	18	5
Decumulation stage	30	40
Notes: a) Falling short of target pension, b) Percentage of plan duration (based on plan lasting 70 years)		

Table 11 Distribution of risk by primary cause	
	Percentages
Plan member	22
Marketing agent	4
Accumulation stage investment strategy	26
Fund manager	21
Decumulation stage investment strategy	11
Annuity provider	10
Regulator	6

Table 12 Distribution of risk by category	
	Percentages
Delayed start of plan	16
Inadequate contributions	18
Interrupted contributions	8
Unsuitable accumulation stage investment strategy	9
Poor investment performance in accumulation stage	19
Premature retirement	8
Unsuitable decumulation product	12
Unsuitable decumulation stage investment strategy	5
Poor investment performance in decumulation stage	5

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