PWL

TARGET WEALTH:
A new approach to the retirement challenge

We can do a better job converting savings into retirement income, but it requires commitment.

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1 Introduction

The historical mainstay of pension planning, the defined benefit (DB) pension plan is disappearing across the developed economies, with now less than half of current pension assets. In Canada an extrapolation of data on DB membership shows the number of active private sector DB plan members drops to zero by 2026[1].

For the retiree, the attractive features of a DB plan are:

- income for life
- a known and fixed income at retirement
- the employer is responsible for any shortfall.

DB plans offer the investor a direct connection between savings today and income tomorrow. This is a quality shared by the Canadian Pension Plan (CPP), and is what most people would understand as a basic property of any pension plan. The main replacement for DB plans is the defined contribution (DC) savings plan. In a typical DC plan, the employee and the employer contribute a fraction of the employee's annual salary to a tax-advantaged fund. The employee is responsible for how the funds are invested, and the connection between savings and future income is lost. The responsibility for converting savings into retirement income, a process known as decumulation, falls to the individual investor.

We observe that the DC plan is not a pension plan, but a savings plan. The DC plan member is exposed to investment risk during both the accumulation and decumulation phases, as well as longevity risk and income risk during decumulation. Most retirees would prefer certainty of income but, unless they have sufficient capital to generate risk free income, they are always going to be exposed to stock markets and the risk of running out of money. The typical components of a retirement savings plan are an employer DC plan and individual RRSP accounts which, collectively, we will consider as a tax-advantaged savings plan. Our goal in this paper to consider different strategies for generating retirement income from a savings plan that matches as closely as possible the DB plan experience.

We proceed by considering some conventional approaches involving annuities, and investment strategies using a pre-defined allocation to stocks, before exploring an adaptive strategy we call Target Wealth. To make the discussion more concrete we introduce Bob, as an example of an investor who would like his savings strategy to match the DB experience as closely as possible.

[1] https://www.theglobeandmail.com/investing/personal-finance/retirement/article-the-extinction-of-defined-benefit-pension-plans-is-almost-upon-us/

2 Annuities? Not likely.

Before we dismiss annuities (and we will) it is important to understand them. A life annuity provides a lifetime income in exchange for a lump sum. As such, the retiree avoids investment risk during decumulation. A unique strength of the annuity for the individual investor is that it also protects against the risk of running out of money, or longevity risk.

An annuity can be a real annuity or a nominal annuity. A nominal annuity will provide a specified dollar amount, for example, $100 monthly. Because future inflation is unknown, the nominal annuity does not preserve future purchasing power. A real annuity preserves future purchasing power by adjusting the payout according to inflation. The owner of a real annuity has traded any potential gain from inflation in return for eliminating the risk of loss. Retirees should be concerned about preserving their spending power, so the real annuity is the risk-free asset for those who value maintaining their purchasing power.

This is in stark contrast to the investor in the accumulation phase who regards market volatility as the primary risk and the GIC (or more generally a short-term government bond) as the risk-free asset. Owning a GIC may insulate an investor against today's market volatility but is a risky asset if the investor needs to preserve their spending power over several decades.

The real annuity is the closest substitute an individual investor can get to an inflation linked DB plan. Yet the market in real annuities is negligible because the assets used to offset inflation are scarce and expensive, and nominal annuities generate a higher payout than real annuities (by 30-40%) because purchasers are exposed to inflation risk. As a consequence, there is one provider of real annuities in the US, and none in Canada[2].

Even nominal annuities are rarely purchased; a review cited 39 reasons (behavioural and rational) to avoid annuitization. Reasons include pricing, the irrevocable nature of the decision to annuitize, and the low cash flow from an annuity in the current low interest environment[3].

From our annuity discussion we take away the important observation that, despite the lack of interest in real annuity, it is the risk-free asset for a retiree and that any meaningful comparison of different retirement strategies should use real rather than nominal values.

[2] At the time of writing the authors were unable to find a provider of a CPI linked (real) annuity in Canada. It is possible to source a nominal annuity with a predefined indexation (0-5%), but payments are not linked to inflation.

[3] Research and reality: A literature review on drawing down retirement financial savings. MacDonald,B.-J.,et al. 2013. North American Actuarial Journal 17:181-215.

3 Longevity Uncertainty

Setting aside annuities means that the retiree is faced with planning an income stream for an uncertain period. To simplify the comparison between different strategies we will assume the retirement period is known. In Canada, one member of a 60-year old couple has a 40% chance of living until age 95[4], and we select this as the upper bound for the retirement period. Although most people will not live to age 95, anxiety about outliving savings is prevalent. But extending the retirement period excessively reduces annual income throughout retirement to cover a small risk of living much longer than average.

In practice, longevity estimates can be updated by taking account of an individual's health during retirement. Also, other assets, such as equity in the home, can be used to provide additional security, if needed.

The remaining discussion will consider how best to structure an investment portfolio, prior to and during retirement, to deliver a fixed annual income during retirement. We introduce Bob as our fictional case study.

4 Meet Bob

Bob is 50 years old with $500,000 in an RRSP. Bob plans to work for another 16 years, retiring at the end of the year in which he turns 65.

Bob is currently adding $10,000 per year to his RRSP, which is matched by his employer, so that his total RRSP contribution is $20,000 per year, made shortly after the start of each year. Bob assumes that this will continue during his remaining working life. Bob assumes that he will be withdrawing $40,000[5] per year from his RRSP for 30 years. In addition, he expects to receive the maximum CPP and OAS, which will total about $21,000. This will give Bob about $61,000 per year of pre-tax income during his retirement. Bob currently makes about $100,000 per year, and does not expect this salary to increase much beyond the rate of inflation over his remaining working life. As a result, Bob is targeting retirement income of about 60% of his final salary. Bob also owns his own house, mortgage-free, which has a current value of about $400,000.

Bob wants to know how best to meet his retirement objectives. His primary concern is minimizing the risk of running out of money before age 95 and he has no wish to leave a legacy from his retirement savings, although his house could be passed on, or used as a contingent asset.

[4] http://app.iqpf.org/guidelines/life-expectancy

[5] All dollar values relating to Bob are in today's dollars (i.e. in real terms)

We determine that Bob needs an annual return of 1.38% from his investments. We call this the breakeven internal rate of return (IRR). The breakeven IRR is the annual return that would, if earned every year for 46 years, allow Bob to withdraw $40,000 per year during retirement and exhaust his savings by age 95. The rate of return might seem rather modest, but remember this is a real rate of return, and we are ignoring investment fees. Assuming a rate of inflation is 1.7%, the nominal rate of return would be 3.1%.

5 The Investment Model

To compare different investment strategies for Bob, we need to establish an investment model which includes: investment assets, data about the performance of those assets and a measure of success. We consider each in turn.

A realistic model has to accommodate the monthly variation of stock market returns, which can be provided from historical data. We constrain our portfolio to consist of only two assets: a risk-free asset represented by one-month government bonds (U.S. T-Bills) and a risky asset represented by the U.S. stock market. We sample from historical data of monthly investment returns, over the period 1926 - 2016 inclusive[6], using bootstrap resampling, a technique explained here. How historical data is sampled impacts the absolute value of the results, but is less important when comparing different investment strategies[7].

The average annual real return from the T-Bills is 0.46% and 8.80%[8] for the U.S. stock market, so investing in the risk-free asset alone will not achieve the break-even IRR. If we ignore stock market volatility, then a blend of 89% T-Bills and 11% stocks would be sufficient to achieve the required annualized return of 1.38%. However, a flaw in this reasoning is that this is only the expected (or average) historical return with this blend of assets. As we shall see, this exposes the investor to a lot of downside risk.

A more careful analysis includes stock market volatility. The calculation is now more complex and involves a distribution of potential outcomes, so we present results in terms of medians and probabilities, rather than a binary outcome of success or failure. A frequently used measure of success is what actuaries call the probability of ruin. In our example, the probability of ruin is the probability that Bob will run out of money before age 95. Arguably, most retirees would be making adjustments to their spending prior to the portfolio depleting to zero but the probability of ruin provides a simple metric for comparing outcomes.

[6] We assume U.S. market data is representative of the experience of the Canadian investor, when factoring in currency conversion. All currency values in the paper are in Canadian dollars.

[7] A key choice is the blocksize: the number of consecutive months of data in each sample. Studies that use large blocksizes significantly underestimate risk. We experimented with different block sizes and considered a blocksize of two years was a reasonable choice.

[8] We quote arithmetic real returns.

When volatility is included, the allocation of 12% stocks results in a probability of ruin of a whopping 49%. This makes this simple strategy untenable. As illustrated in Table 1, a higher allocation to stocks results in a higher average wealth, but the probability of ruin declines and then increases.

Stock allocation	Median wealth at retirement ($'000)	Median wealth at age 95 ($'000)[9]	Probability of ruin
35%	1,214	1,100	9.2%
45%	1,322	1,852	6.0%
55%	1,435	2,821	4.6%
65%	1,553	4,036	4.4%
75%	1,674	5,512	4.4%
85%	1,798	7,260	4.7%

Table 1. Source: Authors' computations

The median wealth at age 95 increases rapidly as the stock allocation increases, so that for higher stock allocations Bob has more money at the end of retirement than at the beginning. If Bob has children, they may appreciate the possibility of an inheritance, but for Bob the additional risk is not delivering a more secure retirement. Bob faces the dilemma of many retirees: taking more stock market risk may improve the average outcome, but not the downside risk. One way to see this graphically is to look at the distribution of investment returns as measured by the IRR.

Figure 1(a) considers the probability distribution of the IRR when the stock allocation is 45%. We see the familiar bell curve of possible IRRs: at the left-hand tail a small number of IRRs are negative and at the right-hand tail there are occurrences of IRRs exceeding 6%. The median IRR (red dash line) is 3.8%, considerably above the breakeven IRR (green dash line).

Figure 1(b) is the IRR distribution for the case when the stock allocation is 75%. The curve flattens, and the median IRR shifts to the right at 5.5% (while the breakeven IRR remains unchanged), as the allocation to stocks increases.

If Bob had a DB plan, he would have no concern about the variability of investment performance because his employer would be assuming that risk. Bob's IRR from a DB plan would be a single value with a probability of 100%, rather than a bell curve.

[9] More technical readers may wonder why we do not consider the standard deviation and mean of the final wealth distribution. The wealth distribution is very asymmetric with a long right-hand tail, so the standard deviation is a poor measure of the range of final wealth, particularly if the primary focus is on the risk of poor outcomes. Similarly, the mean (average) is also skewed by a small number of cases of very large wealth.

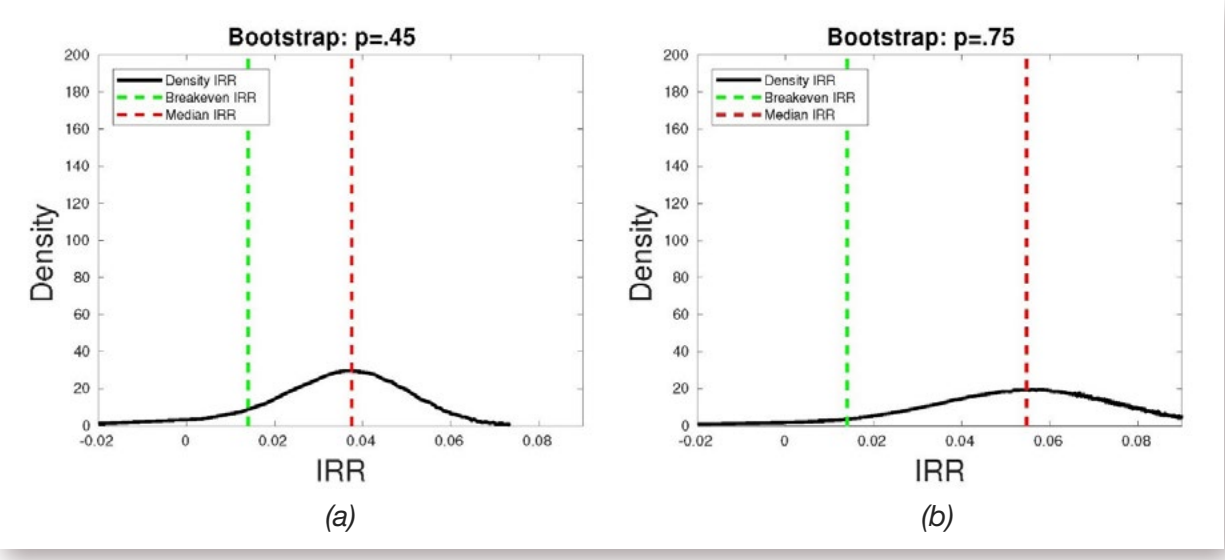

Figure 1 (a,b). Fig 1(a): density of IRR, 45% constant stock allocation. Fig 1(b): density of IRR, 75% constant stock allocation. Source: Authors' computations.

We can imagine Bob making the following observations about our attempts to create a DB retirement experience:

1. *"The probability of ruin seems an inadequate measure of risk – obviously I run out of money before age 95 but I have no idea of the size of the shortfall.*

2. *In most cases I am leaving more money when I die at age 95 than when I retired. I saved this money to live well in retirement – not to generate an inheritance.*

3. *From the distribution of returns, some of the outcomes are really bad and some really good but this seems more of a lottery than the certainty of a DB plan!"*

We consider each of Bob's comments.

6 Meet CVAR

If Bob was insuring his car then he would expect the auto premium to be a function of the product of the probability of having an accident and the typical cost of an accident. Having a history of accidents or driving an expensive vehicle would most likely result in a higher insurance premium.

In our context, a measure that combines the probability and the cost of running out of money is the Conditional Value at Risk (CVAR). CVAR answers the question: if the outcomes are bad what is the average of the bad cases? Or in other words, if things turn out bad, how bad is it likely to be? To be more precise, it is necessary to specify the percentage of the worst outcomes being considered. A common choice is to focus on the worst 5% of outcomes. If, for example, Bob's investment strategy had a 5%CVAR[10] of -$100,000 then, 5% of the time, Bob could expect to have a shortfall of $100,000 at age 95. A positive value of 5%CVAR indicates Bob would expect a surplus, even in the worst 5% of cases.

We show 5%CVAR values in place of the probability of ruin in Table 2

Stock allocation	Median wealth at retirement ($'000)	Median wealth at age 95 ($'000)	5%CVAR ($'000)
35%	1,214	1,100	-324
45%	1,322	1,852	-275
55%	1,435	2,821	-255
65%	1,553	4,036	-265
75%	1,674	5,512	-303
85%	1,798	7,260	-366

Table 2. Authors' calculations

If Bob chooses to maximize 5%CVAR then he will choose a stock allocation of approximately 55%. In this example, a stock allocation of 55% has the largest (least negative) 5%CVAR. Bob considers his house equity ($400,000) as a contingent asset that he would prefer to pass on to his children, but can be used to cover his income shortfall.

So far, we have limited our attention to a constant stock allocation. A common suggestion is that the stock allocation should decrease with age so the portfolio becomes less volatile as the propensity for risk decreases. We consider this in the next section.

[10] We use the 5%CVAR nomenclature to remind us that we are focusing on the worst 5% of outcomes.

7 Is a glide path the right path?

Rather than a fixed asset allocation, we consider a high allocation to stocks initially, which decreases as Bob nears retirement. The idea of taking more risk early on with a high stock allocation and reducing this as you get closer to retirement has an intuitive appeal. This is the thinking behind target date funds (TDFs) which are enormously popular in DC pension plans, attracting more than 50% of pension contributions in the U.S.[11]. The variation of the allocation to stocks with age is known as the glide path and can have a variety of shapes depending on the fund provider. We choose a characteristic model glide path, as shown in Figure 2.

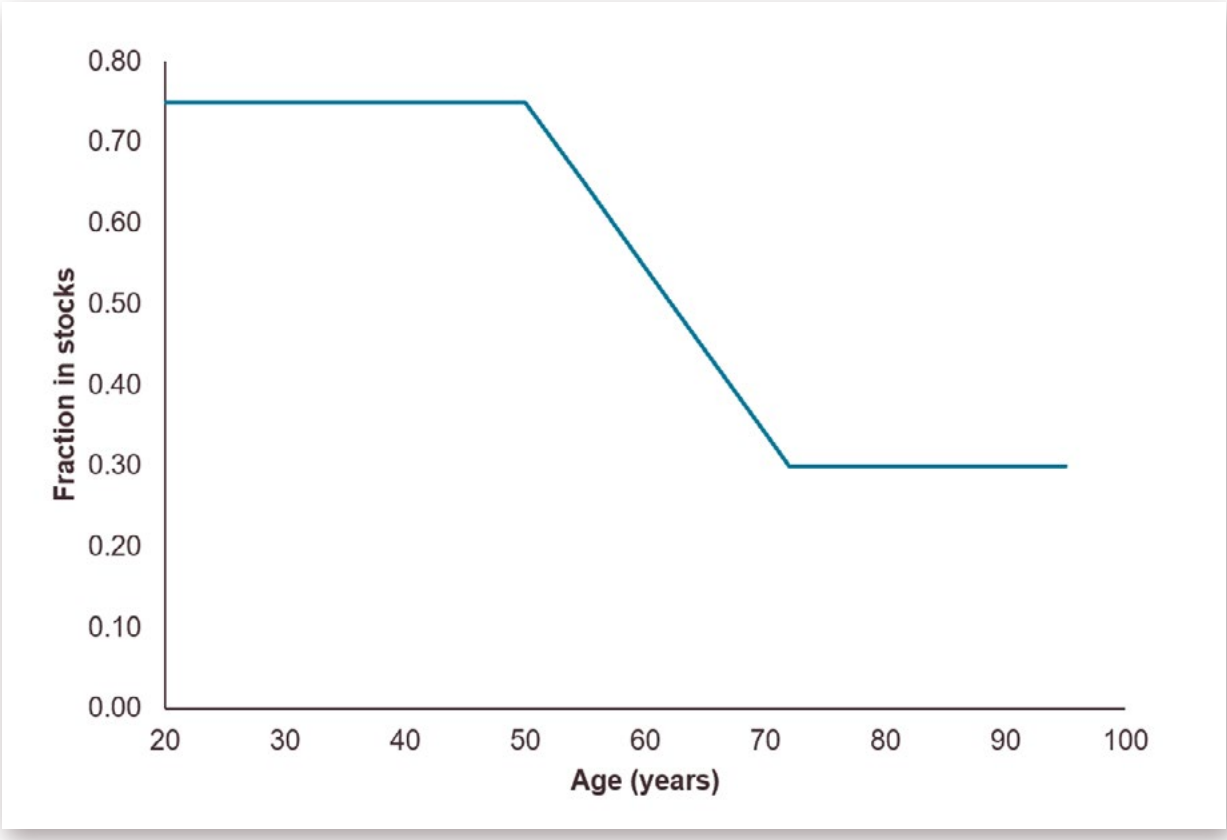

Figure 2. Model Glide Path (MGP). Authors' calculations

The results from our model glide path (MGP) are compared in Table 3 with the closest comparable results with a constant stock allocation.

[11] https://stablevalue.org/news/article/u.s.-retirement-market-trends-assets-continue-to-pour-into-iras-target-date

Stock allocation	Median wealth at retirement ($'000)	Median wealth at age 95 ($'000)	5%CVAR ($'000)
35%	1,279	1,100	-324
MGP	1,489	1,661	-335
45%	1,428	1,852	-275

Table 3. Authors' calculations

We observe that our MGP doesn't offer any advantage over a constant stock allocation. This is consistent with other studies of target date funds – whatever the shape of the glide path there is a constant stock allocation that has a similar performance[12]. Although it is attractive to think of the scenario where markets do well early on, this is when the portfolio is small so the impact is small. Conversely, during later times when the portfolio is large, there is a high allocation to bonds, with low expected returns. These factors roughly cancel out, leaving virtually no improvement over a constant stock allocation strategy. If TDFs don't offer better performance what is their appeal? We suggest part of their appeal lies in their apparent simplicity; the plan participant can simply pick the TDF with a target date corresponding to their intended retirement and "set and forget".

A weakness of TDFs is that a meaningful target is not a date but a secure income over a time period. A TDF takes no account of the current value of the portfolio when determining the stock allocation. Suppose we pose the question at each point in time: Given a specified income over a specified period, and the current portfolio value, what is the stock allocation that provides the best chance of getting to the end of the retirement period without running out of money?

To highlight the weakness of the TDF approach, consider Bob at age 70. If he has followed our MGP then he will set his stock allocation to 30% irrespective of the market value of his portfolio. At one extreme, he may have sufficient wealth ($1,000,000) that he could allocate 100% of his investments into the risk-free asset and still be sure of having enough to provide $40,000 for the next 25 years. Conversely, he could have endured poor market returns to date, and need a higher stock allocation than 30% to maximize his chance of not running out of money. Neither TDF's nor a constant stock allocation respond to Bob's market experience.

[12] https://www.pwlcapital.com/resources/target-wealth-the-evolution-of-target-date-funds/

8 Target Wealth

A constant stock allocation, or an allocation that varies with age, are both what we call deterministic strategies. A different approach is to allow the allocation to stocks to vary according to progress against a specified wealth goal. Because the stock allocation adapts and is not pre-determined, we call these adaptive strategies.[13] An adaptive strategy has the following components:

1. An objective function, usually to maximise or minimise a quantity.
2. Some constraints: things that are not allowed.
3. Criteria for success, such as CVAR.

In a recent paper, we describe the underlying mathematics of stochastic process control and our search for an appropriate objective function. We all use similar strategies to cope with decision making under uncertainty in our everyday lives. Imagine you are driving to the airport to catch a flight. According to your fuel gauge, you have sufficient fuel with a small margin for error. You know that there is the possibility of diversions due to road construction or accidents but can't be sure of their severity. You also know that stopping for fuel will cause a delay and increase the risk of missing your flight. As you continue your journey you continue to update your fuel consumption and gather information on potential delays. You may repeat this experience several times and, in doing so, form an informal model of possible delays at different times of day and at different times of year.

In a similar fashion, we use our two-asset market model to test different allocations to stock at each point in Bob's retirement to estimate the optimal strategy. We found that the most successful approach[14] was to target the residual wealth at the end of retirement, hence the description, Target Wealth.

We fix the terminal wealth we want to achieve and ask at every time period "How does the allocation to stocks have to evolve to maximize the chance of reaching this target, while taking minimum risk?" Establishing the target at the outset and sticking to a savings rate is essential for success: target wealth is a pre-commitment strategy, which is a positive attribute if the goal is to ensure a high percentage of participants have a well-funded retirement.

Risk in this context is falling short of the target, so our strategy penalizes falling short of the target, but does not reward exceeding the target. If markets are favourable, and Bob can achieve his spending goals by investing solely in the risk-free asset, then this is preferable to retaining stock exposure and risk losing past gains.

[13] This is distinct from adapting the stock allocation based on views about the state of capital markets or the economy.
[14] In our paper we explore maximizing CVAR directly and the shortcomings of this approach.

Table 4 shows the results for the various value of target wealth at age 95. For example, TW1000 targets an average value of terminal wealth of $1,000,000. You will notice that we specify a target wealth that is greater than zero. This might seem strange given that we have already stated that our preference that Bob spends all his money during retirement. It turns out that instead of aiming for exactly zero wealth it is better to aim for a positive amount, as this provides a buffer against a sequence of bad returns. In Table 4, we show the median values of final wealth, rather than the average or expected values, since the wealth distribution is skewed. It makes more sense in this case to report median values.

Target Wealth Case	Median wealth at retirement ($'000)	Median wealth at age 95 ($'000)	5%CVAR ($'000)
TW500	1,290	598	-63
TW1000	1,459	1,149	-59
TW1500	1,592	1,722	-133
TW2000	1,694	2,321	-220
TW3000	1,838	3,575	-350
TW5000	1,989	6,299	-459

Table 4. Authors' calculations

We compare the dynamic stock allocation results with the constant stock allocation and the model glide path in Figure 3.

Target Wealth shows a significant increase in 5%CVAR compared to a fixed stock allocation when the targeted final wealth is small. For retirees like Bob, primarily interested in recreating a defined benefit plan experience, this is a very positive development. A larger 5%CVAR implies that the downside risk is much reduced. For reference, we have also added results from the model glide path (MGP).

If Bob were to change his mind and decide that he wants a large terminal wealth, then the Target Wealth approach appears to be at a disadvantage compared to a constant stock allocation. This is a consequence of our decision in the Target Wealth formulation to move surplus cash to the risk-free asset when sufficient wealth is achieved. This limits the potential of Target Wealth in very favourable stock markets compared to a fixed high stock allocation. If we had chosen to invest surplus cash in stocks then, for the higher target wealth cases, the value of the median terminal wealth would be shifted to the right in Figure 3.

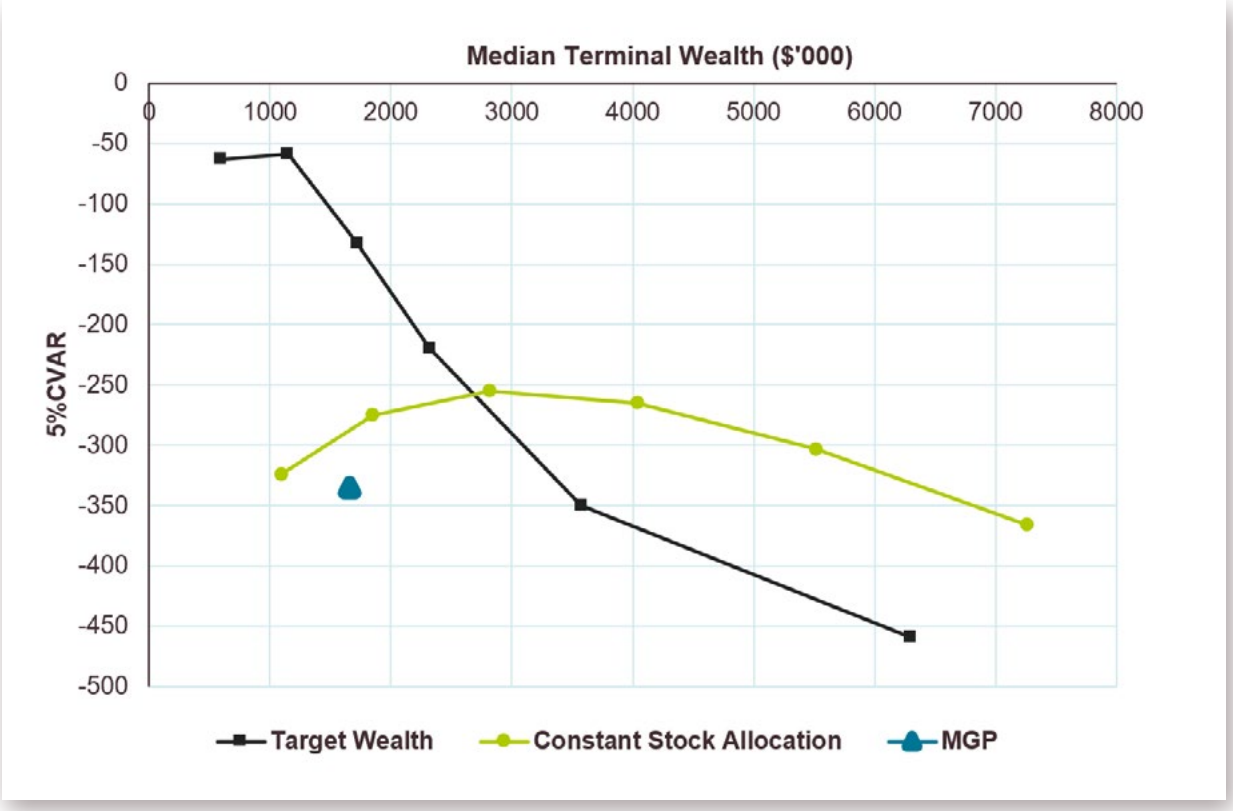

Figure 3. Expected Shortfall, as represented by 5%CVAR for Constant Stock Allocation Strategies (Table 2), The Model Glide Path Strategy (Table 3) and Target Wealth Strategies (Table 4). The Median Terminal Wealth is at the end of retirement at age 95. Authors' calculations.

From Bob's perspective, a defined benefit plan would have zero 5%CVAR and zero median terminal wealth and occupy the top left-hand corner of Figure 3.

Figure 4 shows the time evolution of the percentiles of the fraction in stocks, and the percentiles of wealth for the Target Wealth strategy, TW1000.

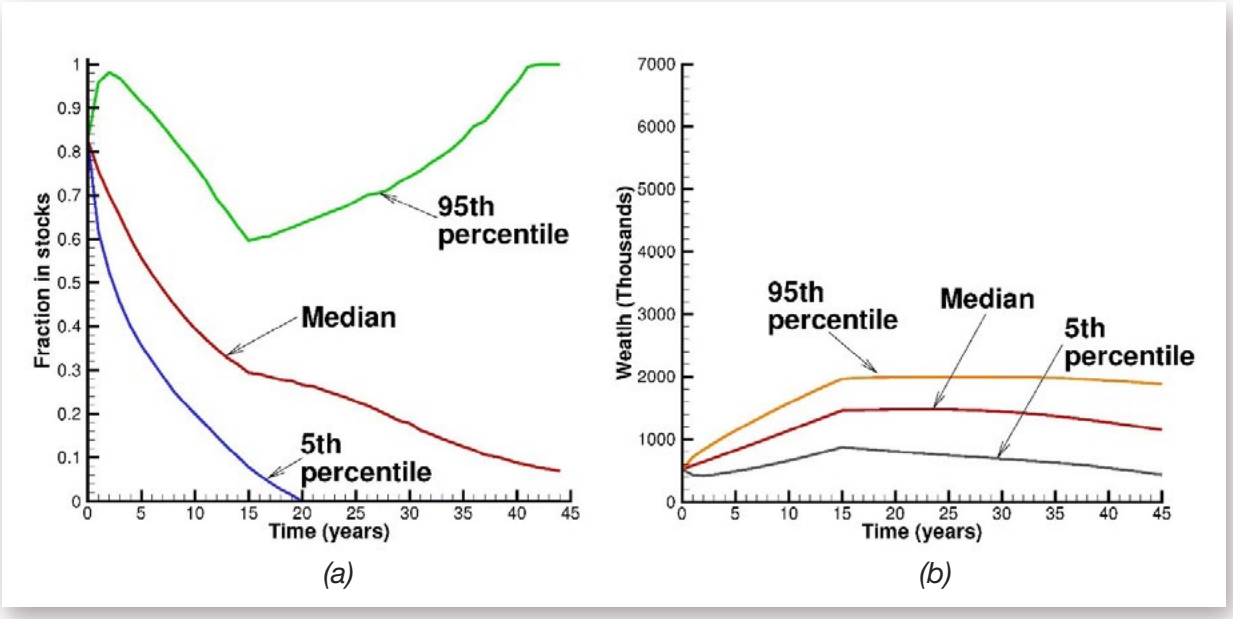

Figure 4 (a,b). Fig 4(a): percentiles of fraction in stocks. Fig 4(b): percentiles of wealth from age 50. Authors' calculations.

We compare how Bob's stock allocation and portfolio value changes with time in Figure 4(a,b). Figure 4(a) shows the percentiles fraction in stocks. 5% of the outcomes would be below the 5th percentile line, so there is a 1 in 20 chance that markets are so favourable for Bob that after 20 years he can exit the stock market entirely, having accumulated sufficient wealth to meet his income needs solely invested in risk-free T-Bills. At the other extreme, as indicated by the 95th percentile, stock market returns are so poor that, when retirement starts, Bob is forced to increase the allocation to the stock market to minimize the risk of running out of money[14]. In the median case, the stock market allocation declines to 30% at retirement (t=15) and continues to decline throughout retirement. Many retirees would welcome the opportunity to reduce their stock market exposure to 30% or less at the start of retirement.

A trade-off is that the potential for large, but unplanned, terminal wealth is also reduced. This is clear from Figure 5 which shows the distribution of the internal rate of return (IRR)) for TW1000. Compared with the IRR distribution with a constant stock allocation (Figure 1(a, b)), the distribution of possible returns is much more compact.

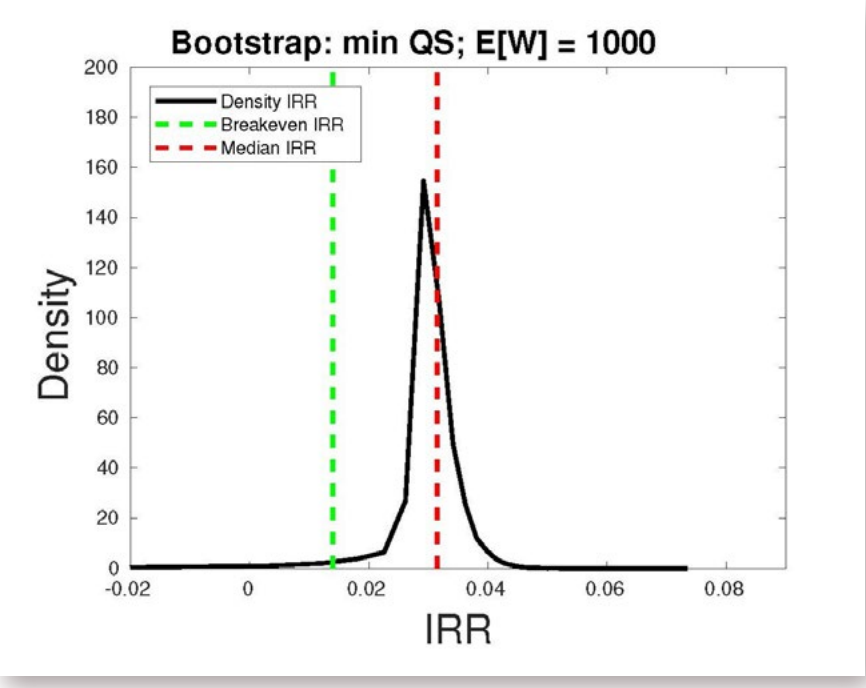

Figure 5. IRR for Target Wealth Case TW1000. Authors' calculations.

[15] This is reminiscent of the "inverse camel hump" strategy: https://www.advisor.ca/investments/market-insights/managing-risk-with-the-clock-ticking/

9 No target, not much success

We have used our journey with Bob to focus on the objective of mimicking the defined benefit plan experience for an individual retiree who wants a constant (real) income stream from a risky asset. No single measure can assess risk, but we make the case for focusing on CVAR as a measure that embraces both the probability and the cost of failure.

We initially focus on the results from deterministic strategies using either a constant stock allocation or, as in the case of Target Date Funds, a pre-defined glide path. We then consider an adaptive, pre-commitment strategy, Target Wealth, that, within the model assumptions, provides an optimal strategy. In the example of our mythical retiree, Bob, Target Wealth reduces the risk of failure, as measured by 5%CVAR, by approximately 80%, compared to deterministic strategies. Bob can also manage the 5%CVAR by means of the equity in his house. In the TW1000 strategy, his house equity is several times the size of the 5%CVAR, so that this risk is hedged to a large degree.

Target Wealth upends the traditional perspective, so that the stock allocation is an *output* to the investment process rather than an *input*. Target date funds are popular because they suggest a single decision about when to retire can fix the investment decision for the intervening years. Target Wealth offers a similar, goal-based approach that is linked to a more meaningful goal of minimizing income shortfall and takes the investor seamlessly through the accumulation and retirement phases.

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