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Beyond Market Volatility: Model Risk in Retirement Planning

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Introduction

During the decumulation phase of the retirement savings lifecycle, an individual's goals are defined as a series of withdrawals. The outcome from any investment strategy, in relation to this retirement goal, is a function of the sequence of investment returns in relation to the retiree's withdrawal profile. The central role of cash-flows and the associated sequence of returns means that risk management and portfolio design for decumulation is fundamentally different than for wealth accumulation.

Monte-Carlo simulation provides an intuitive framework for capturing sequence of returns risk. As a result Monte-Carlo simulation has become an industry standard tool for retirement planning, enabling advisors and retirees to answer important questions in relation to their retirement plans:

"Will we be able to meet our income needs for the rest of our lives?"

"What is the maximum withdrawal level I will be able to sustain?"

"Can I retire at age 60, or will I have to work longer?"

"Will we have anything left to meet unplanned expenses, or to leave to the kids?"

"If investment markets go bad, what sort of shortfall might I expect to suffer?"

By answering these questions, advisors can help retirees understand if their desired withdrawal level is sustainable. They can also identify optimal retirement strategies, taking into account the desired income level and risk profile.

Moody's Analytics believe that Monte-Carlo simulation can be a powerful tool for financial risk management. Since Monte-Carlo simulation focuses on the outcomes from a savings and investment plan, it provides an intuitive basis for communicating and managing risk in retirement plans.

However, many of the existing Monte-Carlo models used in advisory and financial planning software tools have been designed primarily to support only the wealth accumulation phase. These models may be failing to capture key risk factors facing investors during the withdrawal phase. The following case study illustrates the potential impact of this gap, in terms of both unreliable risk assessment and unsuitable investment advice.

Planning in the Decumulation Phase – Beyond Portfolio Volatility

The history of financial risk management includes many cases where a sophisticated model developed to address a specific risk management problem, has at some later date been re-used to address a related but different problem. While the 'new' risk problem may have appeared similar, it included some additional risk exposure, not captured by the model. This risk may have appeared insignificant when applying the existing model to the new problem, but resulted in significant losses at a later date as markets behaved in a particular way. The use of derivative pricing models to manage risk in leveraged hedge funds, or the reliance on "Value-at-Risk" as the basis for managing bank capital are both examples where the critical limitations of a sophisticated risk model were realised only years later..

Many of the Monte-Carlo simulation tools developed for financial planning purposes are relatively straightforward: an estimate of investment portfolio volatility is used to generate thousands of possible return sequences (scenarios). By simulating the financial plan under each of these return scenarios, we create a probability-weighted distribution for the outcome.

For savers accumulating wealth, the primary objective variable or performance metric is the accumulated value of the fund at a specified future date. A simple model, based on portfolio volatility may be adequate in these circumstances. However, in decumulation, where the objective is to support a series of withdrawals, there are other risk factors which become much more important in determining the outcome:

- **Inflation**:
  Assuming withdrawals are being used to fund living costs, most retirees will need their withdrawal levels to increase, at least in line with the cost of living. A period of sustained high inflation will mean the withdrawal level required to meet living expenses will increase faster than expected. Long-dated inflation-indexed bonds might appear expensive, but that is because their coupon payments are exposed to inflation risk.
- **Interest rates**:
  While retirement plans often rely on systematic withdrawal from a portfolio of mutual funds, many retirees will use some form of secure income option to reduce the risk of future income shortfall. Part of the retirement nest-egg may be sold to purchase a variable annuity, TIPS portfolio, or equivalent. The rate at which a retiree will be able to convert their fund into 'secure' income is a function of prevailing interest rates. If interest rates are significantly different from the assumed level, the amount of income the retiree can secure may be higher or lower.
- **Longevity**
  In many cases, retirement planning solutions assume that the retirement plan has a fixed term, based on the period over which the retiree expects to live. In the US retirement market, there has been a historic preference for flexible access to capital. In the UK and Europe, by contrast, pooling of longevity risk in the form of lifetime annuity products remains the default retirement option for the majority. However, by managing a retirement portfolio to a fixed end-point, the retiree is exposed to the risk that they live longer. A model that assumes a fixed end-point discounts the longevity hedging features of a lifetime annuity or lifetime guaranteed withdrawal rider.

By ignoring uncertainty in inflation, interest rates and longevity, retirement planning solutions can significantly underestimate the risk of failure. The consequences of this 'model risk' are real: retirees setting unsustainable withdrawal levels, and selecting investment options which expose them to unacceptable risk of having to make painful changes to lifestyle or retirement plans. These limitations in existing Monte-Carlo retirement modeling solutions, and their potential consequences, were previously highlighted by a report sponsored by the Society of Actuaries [1].

[1] Turner J.A, Witte H. A. "Retirement Planning Software and Post Retirement Risks". December 2009. Sponsored by the Society of Actuaries and The Actuarial Foundation.

In the following case study, we provide an example to quantify the impact of inflation and interest rate risk on retirement outcomes, and retirement planning decisions. To keep the example simple, we will leave our analysis of the impact of longevity risk for another report.

Case Study: Retirement Planning

The following simple case study illustrates the potential impact of model choice on retirement investment advice.

Joe is aged 50, divorced with two children, with accumulated retirement savings of $1,000,000. Joe now works part-time and while his salary covers his expenses including kids' college fees, he expects to make no further contributions to his plan. He would like to stop work at age 60 and estimates he will need to maintain an annual income of around $50,000, in today's money, in order to cover basic expenses plus a few discretionary items. For the purposes of this simple example, Joe would like to maintain these withdrawals until age 85. In addition, he would like to retain flexible access to capital to fund extra expenses, and would like to be able to leave any remaining cash to his kids when he dies.

We will consider two broad strategies for generating stable income in retirement:

Systematic Withdrawal Plan ('SWP'): After retirement, Joe draws the required income from his savings fund which remains invested throughout the withdrawal phase to age 85.

Secure Income Plan ('SIP'): Joe remains invested up to retirement but purchases secure income at retirement, in the form of a TIPS 'ladder' paying income to age 85

For the SWP strategy, and for the accumulation phase of the SIP strategy, we consider the four different investment options, described in Table 1.

Table 1: Systematic Withdrawal Plan - Investment Options

Fund Name	Asset Allocation
Treasury Bonds	100% T-Bonds (10Y Average Duration)
Linker Bonds	100% Index-Linked T-Bonds (10Y Average Duration)
Balanced	30% Linker Bonds, 55% US Equity, 10% Real Estate, 5% Commodities
US Equity	100% US Equity Index

The Moody's Analytics Monte-Carlo model has been used to provide answers to the retirement planning questions described earlier.

To understand the impact of model risk, we consider how the answers to these questions and the associated retirement planning decisions change as we 'turn on' the economic risk factors in the model.

1. What is the probability of achieving the client's retirement income goal?

First, simulate outcomes from the systematic withdrawal plan (SWP) to understand the chance of sustaining the required income, under the four investment options shown in Table 1.

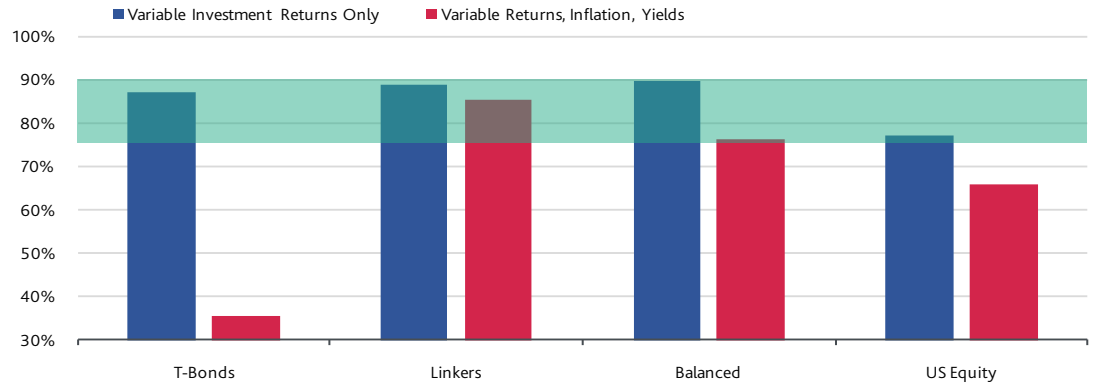
Most retirement planning tools provide a target range for the probability of success. This range can vary, but for purposes of illustration here, we will target a probability of success between 75% - 90%:

- A probability **below 75%** (more than a 25% chance of running out of money) means that the withdrawal level is too high resulting in too much risk of running out of money
- A probability **above 90%** (less than 10% chance of running out of money) means that spending is being sacrificed. The withdrawal level could be increased to support an enhanced lifestyle today, without significantly increasing the risk of future shortfall.

Exhibit 1 shows the probability of meeting the retirement income goal, or sustaining the target withdrawal level of $50,000 in real terms, under the four different investment options. The green shaded area shows the 75% - 90% target probability range.

- The **blue bars** show the result taking into account uncertainty in investment returns (portfolio volatility), but assuming fixed values for inflation and interest rates.
- The **red bars** show the impact of capturing the uncertainty in inflation and interest rates on the probability of achieving the retirement goal.

Exhibit 1: Probability of Meeting Retirement Income Goal - Systematic Withdrawal Plan (SWP)



The blue bars all extend into the "green zone." When we consider uncertainty in portfolio returns only, all four investment options will meet the retirement income goal with a probability in the range 75% - 90%.

However, it is clear that capturing uncertainty in portfolio returns (volatility) is only part of the problem. When the model allows for inflation risk (red bars), the probability of success for all the investment options falls. Two of the four investment options drop right out of the green zone. In particular, for any investment strategy which is likely to be a poor inflation hedge, such as T-Bonds, the impact is drastic.

Ignoring inflation risk will lead us to significantly understate the risk of 'failure' for certain investment strategies. It will also fail to reflect the inflation-hedging features of certain asset classes, like Linker Bonds, or commodities.

With a Secure Income Plan (SIP), Joe will likely have to forego some or all access to capital once he starts to take income. As such, he will fail to achieve one of his key retirement planning objectives. However, the SIP means he will not be exposed to market and longevity risk after retirement. In this case, risk is limited to the remaining accumulation phase, where he remains invested up to retirement at age 60.

In Exhibit 2.1, we show the probability of achieving the target secure income level at retirement:

» The **blue bars** show the result, taking into account uncertainty in investment returns (portfolio volatility), but assuming fixed values for inflation and interest rates. It also assumes that income is secured in the form of a TIPS ladder extending to age 85.

» The **purple bars** add in uncertainty in inflation.

» The **red bars** add in uncertainty in interest rates (TIPS prices), which will determine the rate at which Joe will be able to convert the accumulated fund into an income stream at retirement.

Exhibit 2: Probability of Securing Target Income at Retirement – Secure Income Plan (SIP)

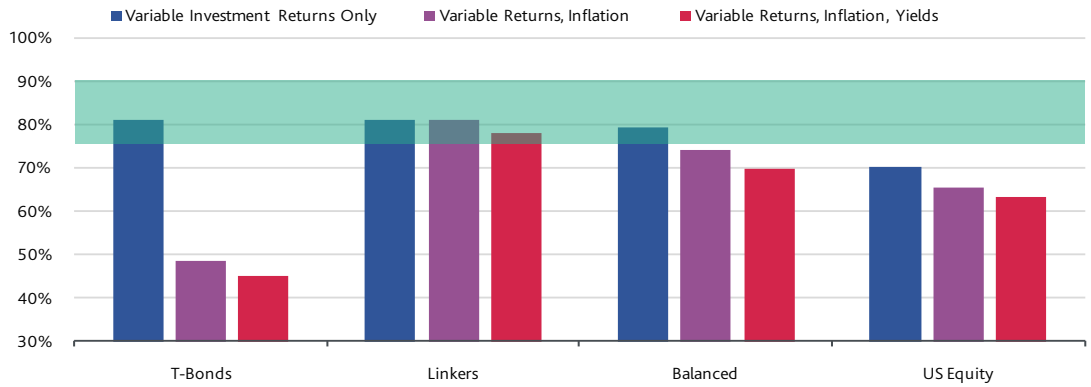


Exhibit 2 shows that uncertainty in both inflation and interest rates impacts Joe's chances of being able to secure his required income level at age 60 under each of the SIP options.

If we consider investment risk only (blue bars), three of the four investment options fall in the "green zone." Achieving the retirement income target with a probability between 75% - 90%. However, when we include inflation and interest rate risk in the analysis, only the Linker Bond strategy remains in this target probability range. Including interest rate risk reduces the probability of success further.

2. What is the maximum sustainable withdrawal level?

Many retirement planning tools evaluate a maximum sustainable withdrawal, referencing a target range for the probability of success. This range can vary, but for illustrative purposes, we find the range of withdrawal levels that can be sustained with a probability of 75% - 90%.

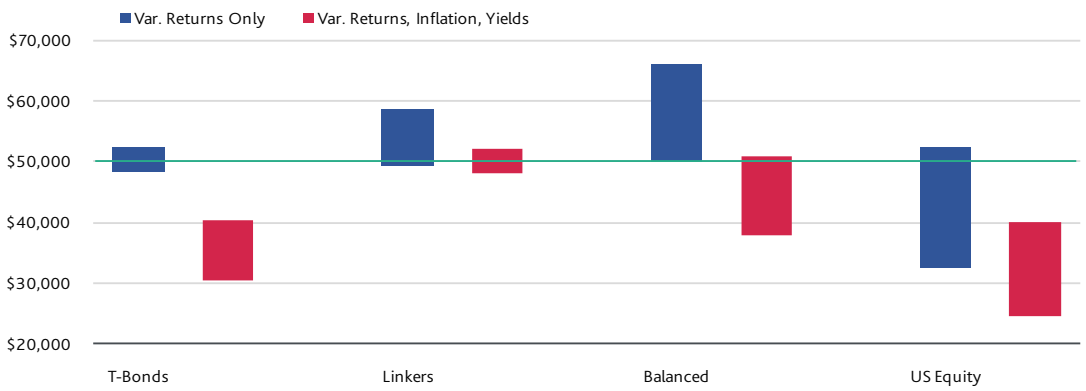
» A probability below 75% (more than a 25% chance of running out of money) means that the withdrawal level is too high resulting in too much risk of running out of money

» A probability over 90% (less than 10% chance of running out of money) means that spending today is being sacrificed. The withdrawal level could be increased to support an enhanced lifestyle today, without significantly increasing the risk of future income shortfall.

Exhibit 3 shows the maximum sustainable withdrawal ranges for the same four investment options. The bottom of the bars denotes the withdrawal that can be sustained with a probability of 90%. The top of the bars denotes the (higher) withdrawal level that could be sustained with a probability of 75%.

Exhibit 3 also compares the sustainable withdrawal level based on portfolio return volatility only (blue bars), with the result after we "turn on" inflation and interest rate uncertainty (red bars).

Exhibit 3: Maximum Sustainable Withdrawal ($ per annum) – Systematic Withdrawal Plan (SWP)



Had Joe's advisor relied on the analysis in the blue bars, he may have recommended the balanced investment strategy, and suggested that Joe could increase his annual income to $60,000. According to this "blue" model, this recommendation lies comfortably within the target probability range 75% - 90%. Once we introduce inflation risk to give a more realistic assessment of the plan, the actual risk of Joe running out of money before age 85 increases to around 40%. For the Balanced fund, the maximum sustainable withdrawal is around $50,000.

By failing to account for an uncertain inflation rate, and the dependence between variation in inflation and investment returns, advisors are at risk of significantly overstating the sustainable withdrawal level.

This risk may lead advisors to recommend withdrawal levels which are unsustainable, exposing clients to increased risk of future shortfall and impairment in lifestyle later in retirement. In this case, the client's retirement plan may be depleted to an extent that it is unable to support extra costs such as later life care or bequests.

The size of the impact is dependent on the details of the investment strategy, and will particularly impact investments that are exposed to inflation risk.

3. What is the optimal investment strategy given the retirement income needs and risk profile?

Having considered the earlier analysis, Joe remains keen to retain access to capital throughout retirement through a SWP.

Joe's advisor considers Table 2, which provides a summary of the "best" investment option against a number of criteria:

- Maximize the probability of achieving the $50,000 income target
- Maximize the sustainable withdrawal level at a 75% probability
- Maximize the sustainable withdrawal level at a 90% probability

In case Joe decides he would prefer a secure income plan (SIP), the table also shows the investment option which maximizes secure income at retirement.

The different rows of Table 2 also show how the best performing investment option depends on whether our model captures inflation, interest rate, and longevity risk:

Table 2: Selection of Optimal Investment Strategy for Different Risk Metrics

Risk Factors Captured		SWP		SIP
Fixed Rate Factors	**Variable Risk Factors**	**Probability of Meeting Income Goal (%)**	**Maximum Sustainable Income (75% - 90% probability)**	**Maximum Secure Income at Retirement**
Inflation Yields	Returns Only	Balanced 90%	Balanced $50,000 - $66,000	Balanced $53,000
	Returns Inflation Yields	Linker Bonds 85%	Linker Bonds $48,000 - $52,000	Linker Bonds $50,500

Important conclusions can be drawn from the results in Table 2:

- Ignoring uncertainty in inflation and yields will likely lead to investment choices which are sub-optimal in relation to Joe's retirement income needs and risk profile (target probability range). In particular, failing to capture uncertainty in inflation will mean that the inflation-hedging property of certain asset classes will be ignored. By capturing the uncertainty in inflation, together with the relationship between the path of inflation and investment returns, it becomes clear that assets without strong inflation protection look much more risky, in terms of the potential failure of Joe's retirement plan.
- The sustainable withdrawal level associated with the "optimal" investment option is sensitive to the choice of model assumptions. Ignoring inflation and interest rate risk will lead us to overstate the sustainable withdrawal level (SWP), or the likely secure income level (SIP).

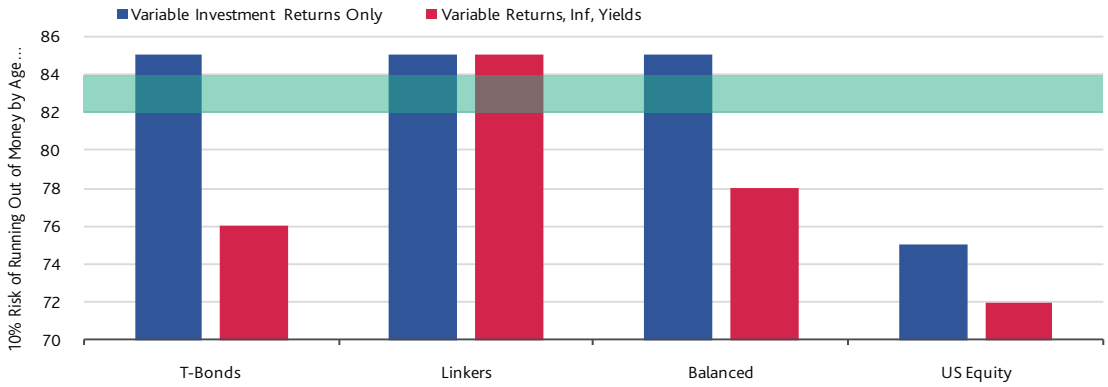
4. What is the potential income shortfall in the recommended retirement plan?

Having selected the preferred "optimal" investment strategy, based on one or more of the metrics detailed above, it is important that Joe understands the potential consequences of unexpectedly poor investment returns, or significant changes in the economic environment. Scenarios that could undermine Joe's retirement plan would include poor investment returns, a sustained period of high inflation, or low interest rates. Given the wide range of economic views on longer term economic conditions, any of these scenarios are possible, and Joe needs to understand whether his plan would hold together under these conditions.

Systematic Withdrawal Plan

With an SWP, the risk is the fixed withdrawals of $50,000 simply burn-down the remaining fund earlier than expected, leaving Joe facing painful adjustments to his lifestyle in retirement. To illustrate these 'worst case' outcomes, Exhibit 4 shows the earliest age at which the fund would run out, assuming a fixed annual withdrawal of $50,000. In this illustration, 'worst case' reflects the worst 10% of the distribution of outcomes from the Monte-Carlo simulation. In 10% of the 5,000 simulations, Joe would run out of money at this age or earlier. A lower probability could be used, reflecting a more extreme economic scenario, but the 10% 'worst case' is sufficient for this example.

Exhibit 4: Potential Income Shortfall (SWP): There is a 10% chance of running out of money by age…



If we take the average life expectancy for a male aged 50 to be around 82–84, then it is clear that relying on portfolio volatility alone will lead Joe to underestimate the potential for exhausting the fund early. This risk could lead to Joe withdrawing too much from the fund, or believing that the recommended investment strategy fits his risk profile, when a more conservative strategy, or one based on different asset exposures would be required to give the protection he needs.

By relying on the blue model, which assumes a fixed rate for inflation, the advisor (or model vendor) is at risk that the actual outcomes for retirees in systematic withdrawal plans prove to be significantly worse than the 'worst case'.

Secure Income Plan

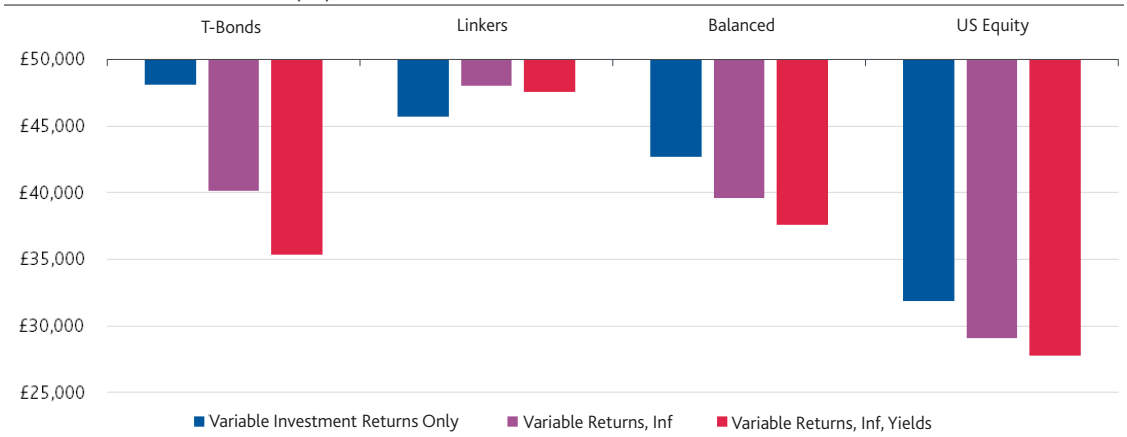
With an SIP, the risk of retirement income shortfall will be realized up to and at retirement. At that point a fixed level of "secure" income is purchased in the form of a life annuity or bond ladder. The risk is that poor returns or low (index-linked) yields will reduce the amount of secure income that can be purchased at retirement.

Exhibit 5 shows the potential shortfall in secure income at retirement. There is a 10% chance that the shortfall, relative to the $50,000 target, will be equal to or greater than the values shown in Exhibit 5.

Again, the different colored bars allow us to compare the potential shortfall under different model assumptions:

- The **blue bars** show the result taking into account uncertainty in investment returns (portfolio volatility), but assuming fixed inflation and interest rates. It also assumes that income is secured in the form of a TIPS ladder extending to age 85.
- The **purple bars** add in uncertainty in inflation.
- The **red bars** add in uncertainty in interest rates, which impact the rate at which the accumulated fund can be converted into an income stream at retirement.

Exhibit 5: Potential Income Shortfall (SIP): There is a 10% chance of a shortfall in secure income at retirement of at least...



If Joe invests his retirement savings in the 'Balanced' fund over the remaining accumulation phase, there is a 10% chance the secure income available at retirement will be less than $42,700 per annum (a shortfall of $7,300), taking into account portfolio return volatility, but ignoring other risk factors.

This potential shortfall increases from $7,300 to $12,500 after we account for inflation and interest rate risk.

Again, we can also see that the impact for investment assets with limited inflation-hedging properties (e.g. T-Bonds) is much more pronounced. By using a model which relies on fixed inflation and interest rates, we will fail to reflect the value in asset classes which act as hedges for these risk factors. This is likely to lead to sub-optimal investment portfolios.

Conclusions

Faced with increasingly stringent tests of "suitability" in relation to investment recommendations, advisors and retirees should expect their Monte-Carlo retirement planning tools to incorporate all the risk factors which will have an important bearing on outcomes.

Many existing Monte-Carlo solutions used in the financial planning sector were originally designed to support wealth accumulation, and fail to capture key risk factors facing investors during the withdrawal or 'decumulation' phase.

However, more robust "economic scenario generator" models, implemented via Monte-Carlo simulation, are the preferred risk modeling solution for insurance companies managing risk in annuity business: the same asset-liability risk management problem as that facing the individual retiree. These models are designed to capture key economic risks such as interest rates and inflation, and the dependence between variation in these risk factors and asset prices.

In a number of European savings markets, where interest rate-sensitive annuity products have been more prominent in retirement plans, integrated economic scenario generator models, which capture the dependence between investment returns, inflation and interest rates, have been widely used to support retirement planning.

Insights in modeling solution design and increases in computing power since the first generation of retirement planning tools was developed, means that the modest degree of incremental calculation complexity required to capture these other economic risk factors can now be delivered to individual retirees and their advisors.