



Stochastic Modelling

The power behind effective financial planning



Contents

Part 01	Overview	3
Part 02	What is stochastic modelling and how does it differ from deterministic modelling?	4
Part 03	The importance of using realistic stochastic models	6
Part 04	Why Term and Risk are Vital to Effective Stochastic Forecasting	8
Part 05	What you should look for in a robust Stochastic Model	10
Part 06	EV's Stochastic Model Insights	11
Part 07	Summary	14
Part 08	Appendix: Good practice principles in modelling DC pensions plans	15



Overview

This document aims to explain what stochastic modelling is and how it can be applied to financial planning. In particular, it highlights the differences between deterministic and stochastic modelling and what you should look for in selecting a robust stochastic model. Key elements include the use of a realistic stochastic model as well as how term and risk are used. More than ever, financial models are being used to assist individuals in making financial decisions and help them evaluate the potential outcomes from different financial strategies. Financial models enable comparisons of different choices before they are implemented to help investors understand the impact of different decisions made.

What is Stochastic Modelling and How does it differ from Deterministic Modelling?

Forecasting is concerned with making projections about future outcomes on the basis of historical and current data. For example, what the investment return on a fund will be in the future is not known with certainty. In order to predict what the future value of a fund could be, estimates need to be made of future economic factors, such as inflation, equity returns and bond returns. There are two main methods of forecasting: deterministic and stochastic forecasts. These are described in more detail overleaf.

Deterministic Forecasts

The most well-known type of forecast uses the same single assumption for the returns on assets. This is known as deterministic forecasting and is typically used by product providers to illustrate possible future returns on long term investments (e.g. pensions). A deterministic forecast produces results which can be precisely determined without any room for random variation. In such forecasts a given input will always produce the same output.

For example, suppose an individual invests £10,000 for 1 year at a rate of interest of 1.5% per annum. Assuming there are no charges, no withdrawals and no contributions made, then at the end of the year it can be predicted precisely that the investment will be worth £10,150. This type of forecast is called "deterministic" because the result is completely determined if the inputs, in this case the interest rate, charges, contributions and withdrawals, are known exactly.

Although deterministic forecasts can provide consistency between providers' product projections they do not give any concept of the risk or likelihood of a particular outcome. They also assume that investment returns will be exactly the same every year even though the timing of high or low returns can make a significant difference to the final fund value. Stochastic forecasts, on the other hand, use many different scenarios to give a range of answers rather than just a single figure.

Deterministic Fund Comparison

Assuming 7% equity return and 2% bond return.



Higher risk will always look better which could mislead investors

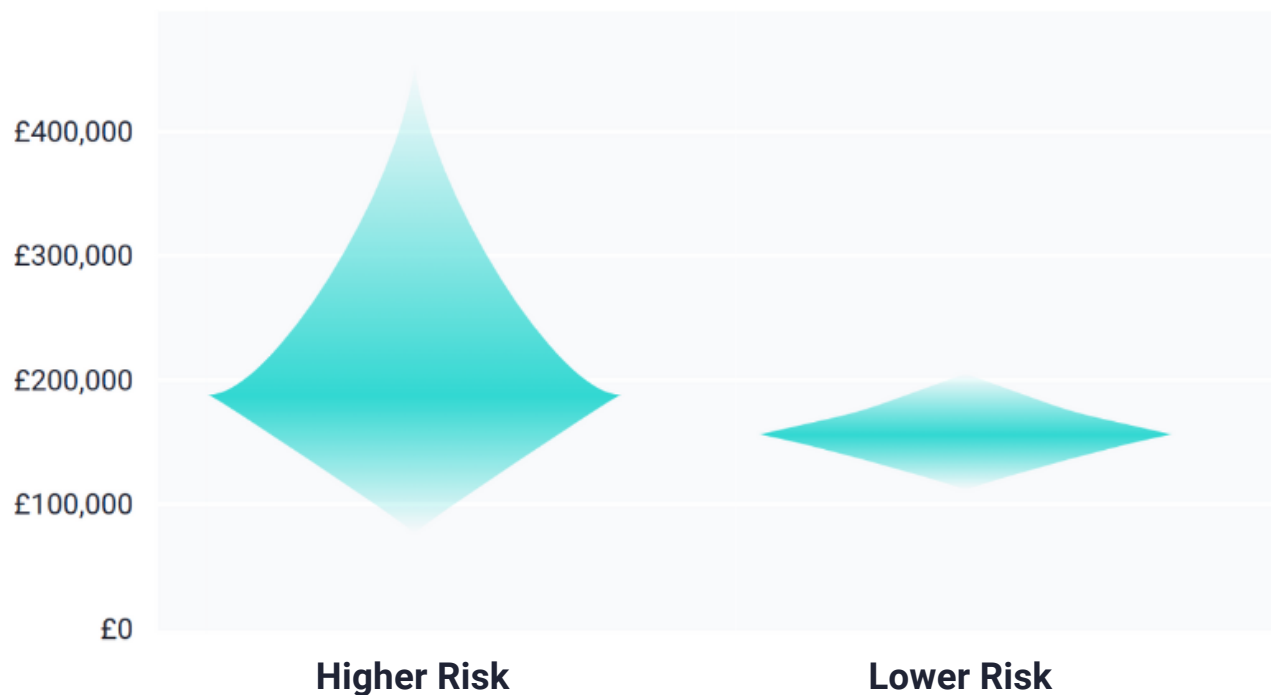
Stochastic Forecasts

Stochastic modelling is a method for predicting outcomes that involve a certain degree of randomness, or unpredictability. Such forecasts determine not only which outcomes are expected to happen but also show those which are less likely to occur. This means that even if the starting point is known there are many possibilities the stochastic process might follow, with some paths being more likely than others.

Rather than using fixed assumptions about future returns, stochastic forecasts show a range of returns produced by a model. Models vary considerably in sophistication and on the inputs required to produce the forecast of different types of asset and economic variables such as inflation. Two types of model commonly used are the Mean Variance Covariance (MVC) models and the Economic Scenario Generator (ESG). Within each of these two types of model there is scope for considerable differences.

To capture the randomness of markets, an ESG is run a large number of times to produce a statistical estimate of the likely returns on a portfolio. Thousands of separate calculations are carried out to produce a forecast based on plausible future economic scenarios. This large collection of future forecasts not only shows which outcomes are most likely but what range can be expected as well.

**Stochastic Fund Comparison Using
1,000 consistent scenarios for equities
and bonds**





The Importance of Using Realistic Stochastic Models

There are two main types of stochastic model used in the market today:

Mean/Variance/Covariance Model (MVC)

MVC stands for Mean, Variance and Covariance where the mean is the average return, the variance is based on how much the market value of an investment changes and the covariance is a measure of how different types of assets behave relative to one another. This type of model makes assumptions about these three elements and presumes that they will remain fixed for all future durations and that this will provide a good guide to the future.

Economic Scenario Generator Model (ESG)

An economic scenario generator (ESG) has complex algorithms which model how the economy and various factors interact with each other. Combined with various calibration factors and assumptions this allows a real world model to be created of the world's economies, from which asset classes and other returns can be created.

Risk Rating Metrics - Different Methods used

The quality of an MVC model is highly impacted by the choice of time period over which performance is measured. This is a somewhat arbitrary decision for which choosing a period that is too long, too short, or is a different period across different asset classes will lead to flawed and unrealistic results. For example, too short a period may not give a true long term indication but choosing too long a period will include factors which are no longer relevant.

MVC models also take no account of how long an investment is held for, as they assume the same average return irrespective of the investment term. In reality risk and return characteristics of assets vary depending on the term of the investment. MVC models should therefore be used very cautiously for longer term projections and an awareness of their limitations is critical when using the output.

In contrast, an ESG can forecast outcomes for investments on a more realistic basis. ESG forecasts do not depend on historic performance. This keeps the forecasts firmly looking forward from the current economic situation. An ESG model builds a large number of possible sensible and realistic economic scenarios by reproducing the fundamental real life characteristics of assets and looks at the range of resulting returns.



Good Practice Principles in Modelling Defined Contribution Pension Plan

In February 2022, the Journal of Risk and Financial Management published a paper*, originally published in September 2013 by the Pensions Institute at Cass Business School, which sets out 16 good practice principles for modelling Defined Contribution (DC) schemes. The first 15 principles, covering areas such as model specification and calibration, modelling member choices, characteristics and longevity risk, were set out in the initial consultation document which was published in March 2013. The 16th principle, that the model should be fit for purpose, was included as a result of the feedback received during the consultation period. EV's stochastic model meets all of the 16 good practice principles. These are set out in detail in the Appendix.

*Dowd K, Blake D. Good Practice Principles in Modelling Defined Contribution Pension Plans. Journal of Risk and Financial Management. 2022; 15(3):108. <https://doi.org/10.3390/jrfm15030108>

Why Term and Risk are Vital to Effective Stochastic Forecasting

When constructing a portfolio, not only are an individual's investment objectives important but so too is their investment time frame. The individual may only be looking to invest their money for a short length of time or they may wish to remain invested for the long haul. Either way, time horizons should always be considered when selecting investments since the time period associated with a given investment objective is fundamental in determining the most suitable asset classes to be held within an individual's investment portfolio.

ESG forecasts can realistically take into account the characteristics of the assets depending on how long they are held. Without this variation by term the forecasts would not be able to reflect reality.

How the same fund is risk rated over different timescales

Risk benchmark: EV Standard 10 [Add a new risk benchmark](#)

Investment term: 15 years

Portfolio name	Risk rating ?	Risk Score ?	Funds
Portfolio 1	1 2 3 4 5 6 7 8 9 10	3.54	L&G Multi-Index 4 I Acc

Risk benchmark: EV Standard 10 [Add a new risk benchmark](#)

Investment term: 25 years

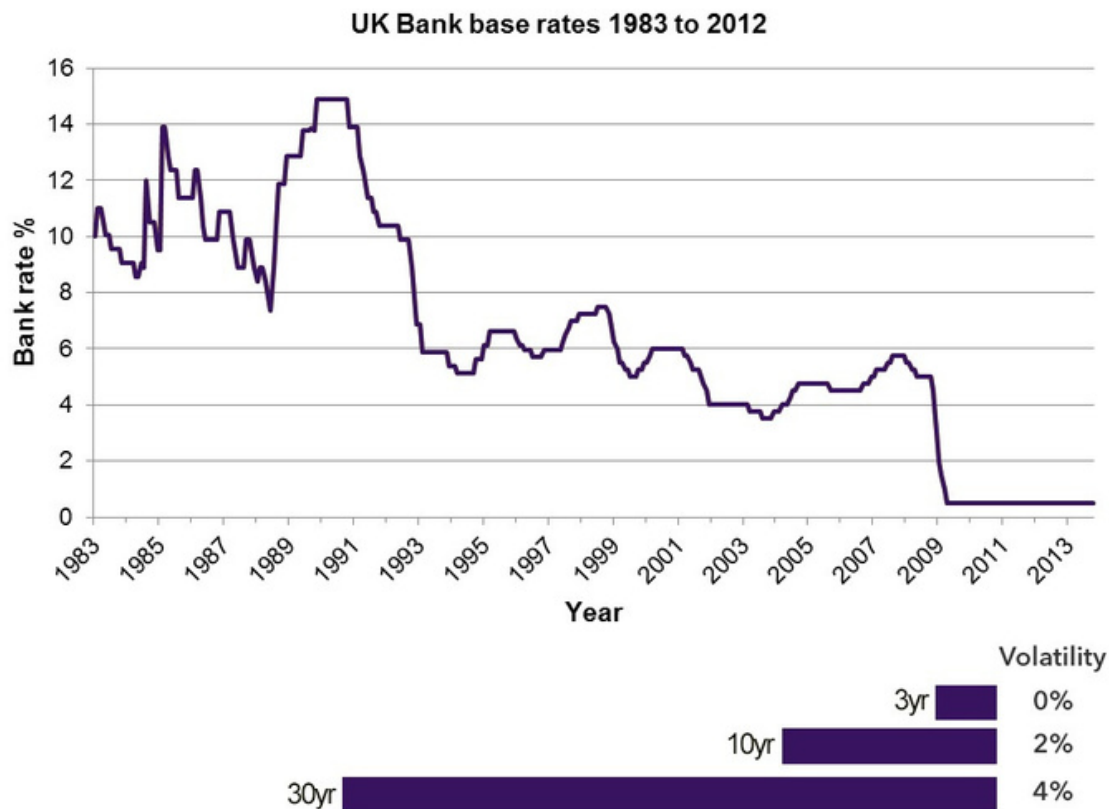
Portfolio name	Risk rating ?	Risk Score ?	Funds
Portfolio 1	1 2 3 4 5 6 7 8 9 10	2.03	L&G Multi-Index 4 I Acc

The Term Dependency of Investment Risk

It is important to appreciate that asset classes have varying degrees of riskiness depending on time. For example, cash has little or no variation in return in the short term however over longer periods interest rates can vary dramatically leading to much greater variation in return.

Understanding risk is an important factor in understanding investments. Risk can be explained using stochastic forecasts by showing the potential upside and downside of each asset class, as well as the chosen combination of assets. This is almost impossible to do with a single estimate, or even a range of single estimates.

UK bank base rate volatility varies by time horizon, increasing with term



What you should look for in a robust Stochastic Model

Stochastic modelling is complex. However, the output of any stochastic forecast is only as good as the quality and strength of the asset model that is used to derive the future asset returns. Advisers should probe the following areas to ensure the robustness of any stochastic model.

Purpose of the model

Like all models, asset models are built for a variety of uses. For retail investors, the model used should have been built specifically to provide a consistent set of long term forecasts of asset returns which can be used to produce strategic term dependent asset allocations. Models built for other purposes are unlikely to be suitable. These include those built to support short term tactical asset allocation decisions such as MVC models.

Real world model

The type of model used should be real world i.e. it seeks to model investment markets as accurately as possible. It therefore must reflect real investment attributes such as the term dependency of risk and return associated with different asset classes. MVC models are not “fit for purpose” as they cannot model “real world” characteristics such as the term dependency of risk and return.

Economic Scenario Generator (ESG)

The model used should be a comprehensive ESG which has linkages between economic variables, currencies and asset returns so that consistent long and short term forecasts of global investment markets and economic variables can be produced

Model calibration

The data used to calibrate the model is extremely important and care needs to be taken to ensure that the characteristics of different asset classes are compared over the same period and that any series of data does not contain inconsistencies arising from fundamental market changes.

Regular updates

The model should be regularly updated, at least quarterly, to reflect changes in current market conditions since future forecasts of returns must take account of where the market is starting from.

Maintenance and upgrades

The model must be maintained and upgraded to reflect market changes. In addition the data used to calibrate the model should be reviewed at least once a year.

Transparency

Documentation on the construction of the model should be available. Regular updates should be published showing changes to the model's output with reasons for these changes. The calibration process should also be documented and key parameters published.

Back-testing

How well has the model actually performed in the past? The results of back-testing (seeing how past forecasts or asset allocations have worked out in practice) should be available.

Team

The strength and depth of the team should be reviewed. The stability of the team is key. Turnover of staff can be a cause for concern.

Commitment of the firm

How important is the maintenance and running of the model to the firm's business? If stochastic modelling is seen as peripheral, it may be starved of the investment needed to ensure that it is delivering top quality results.



EV's Stochastic Model Insights

At the heart of EV's solutions lies a robust and market-leading stochastic asset model. EV's asset model is a real world ESG model which produces realistic forecasts of possible future investment returns enabling investment risk and return to be communicated more effectively. Not only does EV's asset model aim to help investors understand the risks they are taking on over different timescales, it also enables them to have realistic expectations about the outcomes that may be achieved and make sensible decisions about the investment opportunities that are available to them.

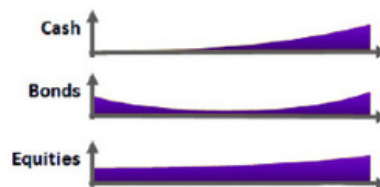
The economic structure of EV's asset model results in plausible future outcomes that are sensible and consistent both in terms of individual investment paths and in aggregate. Modelling interest rates is of fundamental importance when modelling return and risk over the long term. When interest rates increase, the future expectations for cash and bond returns rise. Other assets classes also have some dependency on interest rates. In addition the relative strengths of different currencies are also linked to interest rates, which determine the market expectations of future exchange rates. To this end, EV has carried out recent work on 'state-of-the-art' interest rate modelling which has resulted in a cutting edge model designed to provide the most realistic view of the potential evolution of interest rates over the long term.

What are the strengths of EV's Stochastic Asset Model?

Takes into account term of investment



We include how the characteristics of each asset class varies by term

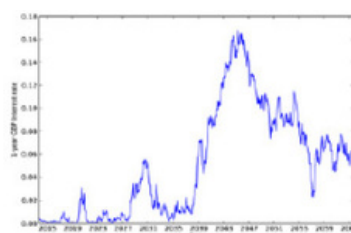


We don't have a fixed assumption for volatility which remains unchanged throughout

Cutting edge model



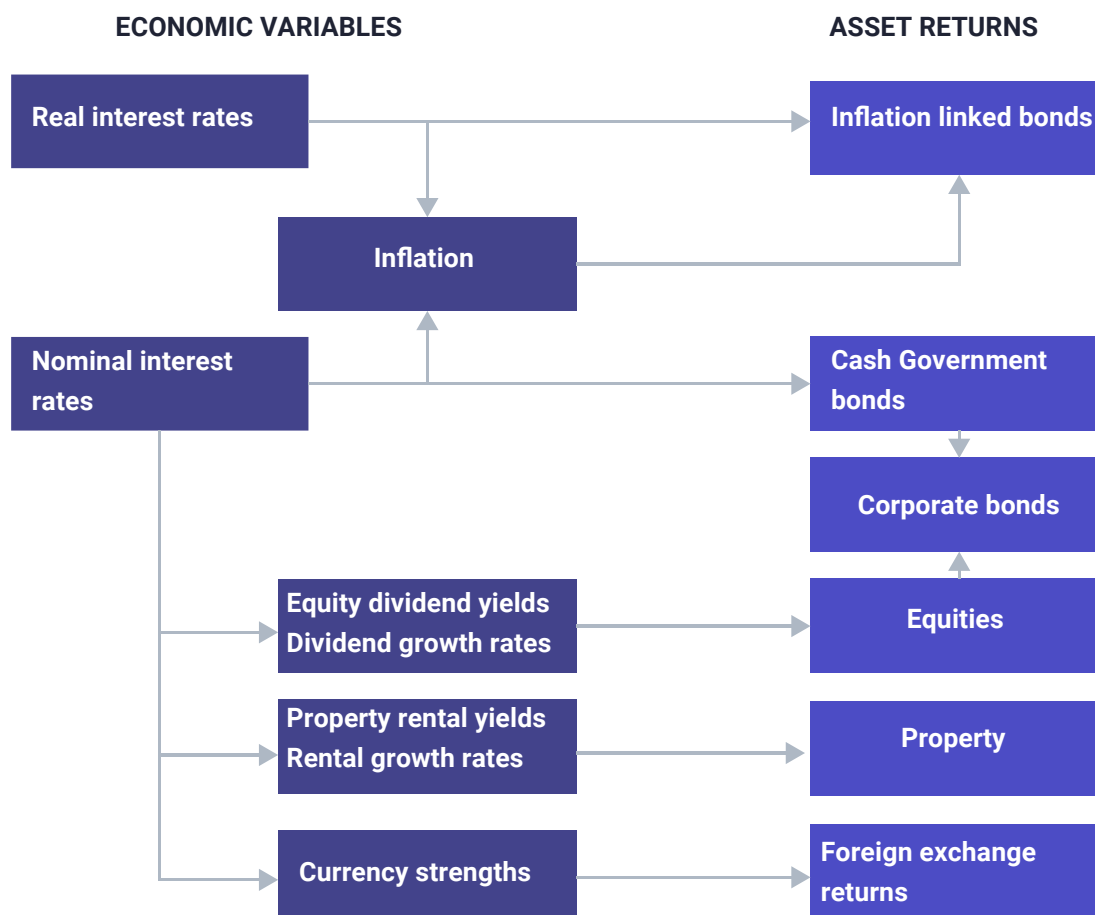
Provides a realistic view of the evolution of long term interest rates



(Graph shows a sample interest rate path with extended periods of low and high rates)

- An economic model which is used to generate future scenarios, rather than using historical data and a simple MVC model to illustrate how an investment strategy or asset will perform in the future
- Only one economic model is used so that there is consistency in the returns of different asset classes and economic variance - one with another and over time EV's stochastic asset model is based on data from each major economic market currently covering the UK, Japan, the US, the Eurozone, Asia-Pacific ex Japan and Emerging Markets Designed to provide realistic simulations of currencies ensuring that the risk of investments held in other currencies is not understated
- Extremely flexible and able to model current and emerging asset classes, products with guarantees and global economies and their currency movements Encompasses the latest thinking e.g. low interest rate environments EV's stochastic asset model includes controlled risk premia reflecting real world behaviour. Controlled risk premia ensure that the expected level of returns is realistic when compared with the level of risk and that the asset allocations based on the model will not unduly favour any asset
- Meets all the good practice principles in modelling DC pension plans (see Appendix for further details)
- On-going investment and dedicated support
- Quarterly updates of assumptions
- Regular recalibration
- On-going refinement
- EV has a dedicated team of experts who maintain and refine the model

Structure of the EV Asset Model





How is the EV Asset Model maintained?

EV's model is updated at least every quarter to take account of changes in market conditions. New scenarios are produced following the update. Between quarterly updates there are monthly reviews to see how returns and asset allocations are trending together with interim reporting. EV can report on interim developments in the model allowing those managing services based upon the model to understand likely developments well in advance of their implementation.

The commitment to keep the model up to date means reflecting changing economic circumstances in the model. This is done by rerunning the simulations with assumptions changed to reflect new economic circumstances. In principle that could mean changing any feature of the model. Indeed, EV's model is as far as possible time homogeneous, which means that when the model considers a future state of the economy it does so in the same way it would if that were the current state. Specific considerations in maintaining EV's models include calibration of model parameters and quarterly reviews, although in practice changes are usually made annually.



Summary

Deterministic forecasts, using a single rate of return, are potentially misleading and dangerous because a risky asset class will show better returns and will ignore the higher risk that is implicit in those higher returns. Therefore such projections will systematically show investments with a higher risk as having higher projected forecasts. This will lead to individual's making investment decisions with a vital piece of the jigsaw missing unless the forecasts can also show that there is a higher risk associated with those assets. The best way of providing forecasts which can help explain investment risk is to use a robust stochastic model. Stochastic forecasts help build up a complete picture of the potential future investment returns over a particular time and mix of assets. Investment risk can be easily explained by showing the potential upside and downside of each asset class, as well as the chosen combination of assets.

This is almost impossible to do with a single estimate, or even a range of single estimates. EV's model is a real world system which considers a range of potential outcomes and shows the variation of these for each investment choice. This helps to make it clear to investors both the potential risk and return of their investment decisions. Therefore expectations are better managed which has to be good for both the consumer and the industry.

Appendix: Good practice principles in modelling DC pensions plans

Good practice principles in modelling DC pension plans	How EV meets the good practice principles in modelling DC pension plans
Principle 1: The underlying assumptions in the model should be plausible, transparent and internally consistent.	Current market data is used for the initial assumptions in EV's model. Consensus forecasts about assets class returns and economic factors are used as the basis for setting the long-term assumptions. The underlying assumptions are reviewed quarterly on a global basis using statistical analysis and input from economists.
Principle 2: The model's calibrations should be appropriately audited or challenged and the model's projections should be subject to back testing.	Calibration of the parameters in EV's model is reviewed each quarter, although in practice changes are usually only made annually. The calibrations are set by analysing historic data and in particular the relationships between various economic variables. Back testing of long term returns demonstrates how well EV's model has performed as a predictor of long term returns.
Principle 3: The model must be stochastic and be capable of dealing with quantifiable uncertainty.	EV's model is stochastic and is a real world system used to generate economic scenarios year by year, with the returns generated in each year being dependent on the returns generated in the previous year. EV's stochastic model makes what is known about uncertain future prospects more precise and it robustly and consistently reflects the important characteristics of a very wide range of assets.
Principle 4: A suitable risk metric should be specified for each output variable of interest, especially one dealing with downside risk. Examples would be the 5% value-at-risk and the 90% prediction interval. These risk metrics should be illustrated graphically using appropriate charts.	EV's model shows 90% of the outcomes generated together with the chance of reaching specific targets. The best and worst 5% of outcomes are not shown in the forecasts. Value at risk (a target of capital loss) can also be entered on EV's tools for lump sums.

Principle 5: The quantitative consequences of different sets of member choices and actions should be clearly spelled out to help the member make an informed set of decisions.	EV's model allows individuals to test the effect of making changes to the complete range of factors affecting retirement income e.g.: • future contributions can be varied in any way the individual wishes e.g. in line with retail prices, national average earnings or in any pattern specified by the individual year by year; • the asset allocation of every individual investment can be changed; • retirement age can be changed and phased retirement options can be investigated; • investments can be reassigned from other goals to enable alternative priorities to be investigated; • the effect of changes in anticipated future salary increases can be tested; the effect of changes in the type of annuity can be reviewed.
Principle 6: The model should take account of key member characteristics such as occupation, gender and existing assets and liabilities.	Personal information used by EV's model includes the following: • Date of birth; • Planned retirement age; • Salary and other income together with marginal tax rate; • Anticipated increase in salary relative to inflation; • Gender. Financial information used by EV's model covers the following details: • Mortgage and other debts; • All types of personal insurances and employer provided risk benefits; • Current and past pension arrangements; • All forms of UK investments e.g. cash deposits, ISAs, PEPs, National Savings Certificates, unit trusts, investment trusts, direct holding of equities, direct property investments; • Anticipated inheritances; • State benefits e.g. basic state pension, SERPS, S2P, graduated pension
Principle 7: The model should take into account the full set of plan charges.	The EV model can include initial and on-going charges, which may vary by client. Tiered charges and fixed £ amount charges can also be taken into account
Principle 8: The model should take into account the full set of plan charges.	The EV model shows the annuitised income which takes into account longevity. Increases in life expectancy are taken into account within the assumptions

Principle 9: The model should project both at-retirement pension outcomes and postretirement outcomes. The risks associated with the following strategies should be clearly illustrated: The risk of taking a level rather than an index linked annuity in terms of a reduced standard of living at high ages. The risk associated with drawdown strategies in terms of taking out more from the fund initially than is justified by subsequent investment performance.	EV's model is able to deal with pre and post retirement outcomes consistently and, stochastically, is the only model currently on the market with a fully integrated engine that covers all types of cashflow. EV's model clearly illustrates the effect of changing the following: • the amount of the initial balance available to • provide a retirement income; • the proportions applied to conventional, investment linked annuities and income drawdown; • conventional annuity options; • investment linked annuity options; • income drawdown options
Principle 10: The model should consider the pre-retirement and post-retirement periods in an integrated way. This is necessary to avoid undesirable outcomes at a later date – such as a big fall in the standard of living in retirement. It will also help to determine what adjustment in member choices – in terms of higher contribution rate, an increased equity weighting and later retirement - are needed to avoid this.	EV's Lifetime Cashflow Tool deals with changes in circumstances pre and post retirement in an integrated way but including stochastic robustness with risk
Principle 11: The model should consider other sources of retirement income outside the member's own pension plan. These include the state pension and home equity release. A well-designed DC model will also help with lifetime financial planning.	The ability exists to enter multiple pension arrangements e.g. personal pensions, stakeholder pensions, AVCs, FSAVCs, transfer plans, retirement annuities. Occupational plans can be included as deferred pensions or as a current arrangement. There is also the ability to set up all the major types of DB, Hybrid and DC pension schemes. The full range of non-pension investments can be included with allowance for the appropriate tax treatment. Property investments, equity release, inheritances and State pensions can also be included.

Principle 12: The model should reflect reality as much as possible and allow for such extraneous factors as unemployment risk, activity rates, taxes and welfare entitlements.	The economic structure of EV's asset model results in plausible future outcomes that are sensible and consistent both in terms of individual investment paths and in aggregate, with the ability to take into account a number of extraneous factors.
Principle 13: Scenario analysis and stress testing are important. For any given scenario, one should also: Make key assumptions explicit; Evaluate key assumptions for plausibility; and Stress test assumptions to determine which really matter and which do not. This allows the modeller to determine the important assumptions and focus on getting them (as much as possible) "right".	The model specifies the relative probability of different future paths for the whole economy. To perform calculations on this model EV samples a set of scenarios according to this probability. Each scenario is a potential history for the economy showing returns for each asset class for each year of the simulations. EV can then see what happens to an investment plan in each scenario. With that information averages, standard deviations, worst cases and so on can be found. EV works hard to keep the model as simple as possible to allow empirical calibration processes and to make sure that the estimates are compatible with the history of events that EV is assuming were governed by the modelled process
Principle 14: The model will need to be updated periodically and the assumptions changed. Such modifications should be carefully documented and explained in order to make sure the model retains its credibility with users.	EV follows a systematic and quantitative update process. EV's model is updated at least every quarter to take account of changes in market conditions. New scenarios are produced following the update. A quarterly report is published detailing the updates and any changes which have been made to the model. Between quarterly updates there are monthly reviews to see how returns and asset allocations are trending together with interim reporting. EV's interim reports can show any developments in the model, allowing those managing services based upon the model to understand likely developments well in advance of their implementation.
Principle 16: The model should be fit for purpose.	EV's asset model is a cutting edge model. It is designed to offer the most realistic view of the potential evolution of interest rates over the long term and reflect real investment attributes, such as the term dependency of risk and return associated with different asset classes. Thus providing individuals with the best possible understanding of their investment options.



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