ESS Calibration Update

2020-03

ESS Team

Wednesday, 13 May 2020

Introduction

This document is intended to provide consultants and other interested parties[1] with a high-level overview of the Economic Scenario Service (ESS), our proprietary economic scenario generator (ESG). The document is refreshed on a regular basis by the ESS Team and includes:

- A short description of the ESS and how it can be used;
- An illustration of the changes to the summary statistics generated from ESS output, which are primarily driven by changes in market conditions. More material movements stemming from model changes will be communicated separately, and in more detail;
- A snapshot of projected returns, volatilities, and other relevant outputs associated with the key building blocks (i.e. models) of the ESS;
- A brief description of the structure of the ESS, i.e. the different models within the ESS and how they relate to each other;
- A summary of the general approach to model calibration;
- An overview of the governance framework for the ESS, i.e. the process by which decisions relating to model choice or calibration methodology are made.

We have avoided delving into the details of the models in order to control the document's length; please speak to the ESS team if a more in-depth description of any aspect of the ESS is needed.

What is the ESS?

An Economic Scenario Generator (ESG) is a collection of mathematical models that enable us to generate thousands of random, but plausible, scenarios of what might happen to economic and financial variables (such as interest rates and stock market returns) at future time horizons. The ESS is a particular example of an ESG.

The models within the ESS are statistical models that are intended to mimic the statistical properties of the returns and rates, rather than explain or predict any particular future. The range and dispersion of outcomes are usually more helpful to consider than only the average across all of them. The model projects financial economic variables over multiple time steps beginning from current market conditions. The fundamental uncertainty about the future means that we cannot know all the information sources that would be needed to inform projections; however, historical evidence suggests that the statistical impacts of the unknown economic and financial drivers are reasonably stable even if the drivers themselves change dramatically over time.

There does of course remain the chance that the political economy or market constructs break down or change completely (e.g. a move from a broadly capitalist to a communist system); the ESS does not allow for those very rare, but potentially very extreme scenarios.

The models within the ESS are chosen by finding a balance between:

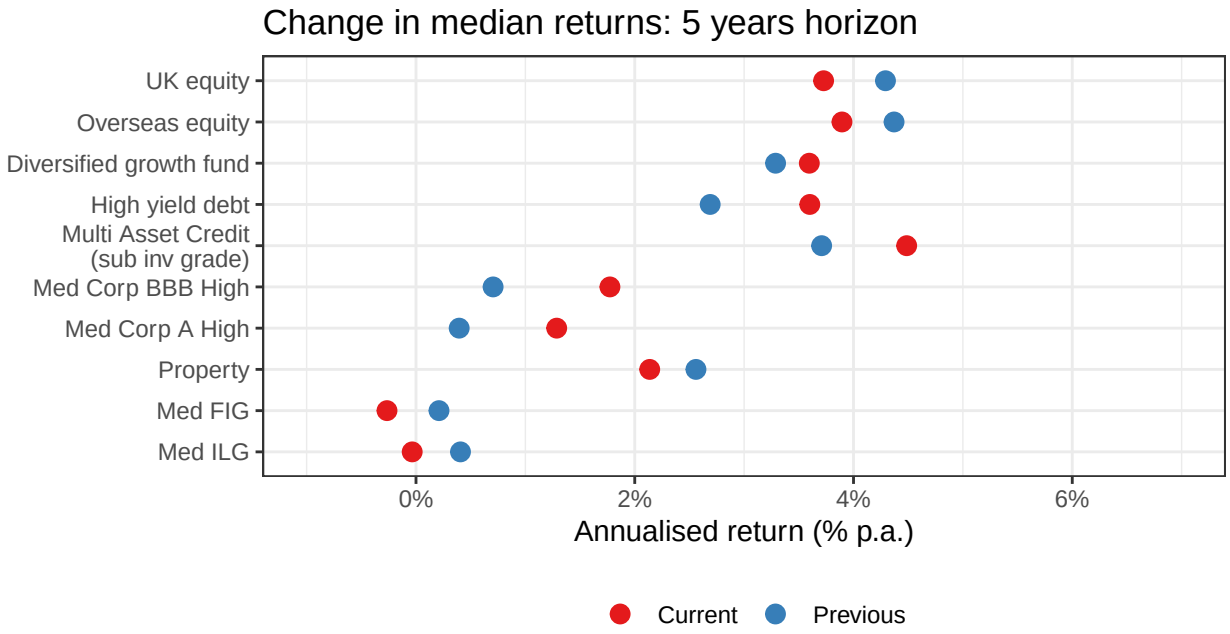
[1] E.g. clients who take an interest in the technical details underlying our stochastic modelling.

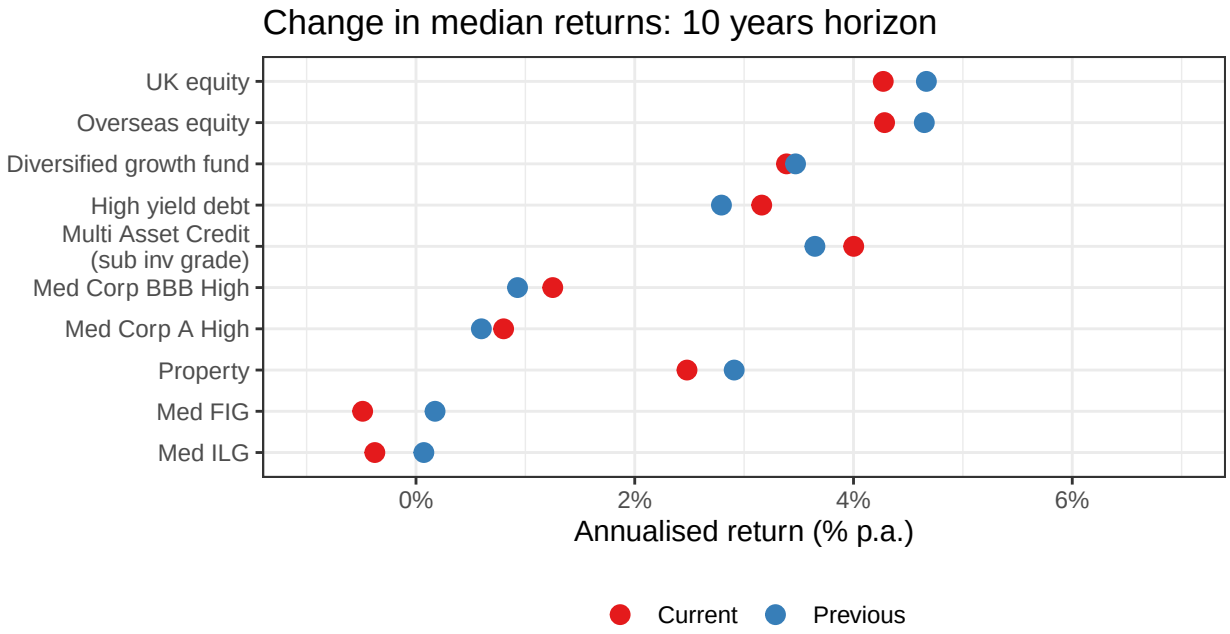
- **Realism** to ensure our models capture important features of the variables we wish to model;
- **Tractability** so that we can exert control over the statistical properties of the models, and efficiently calculate important quantities such as prices.

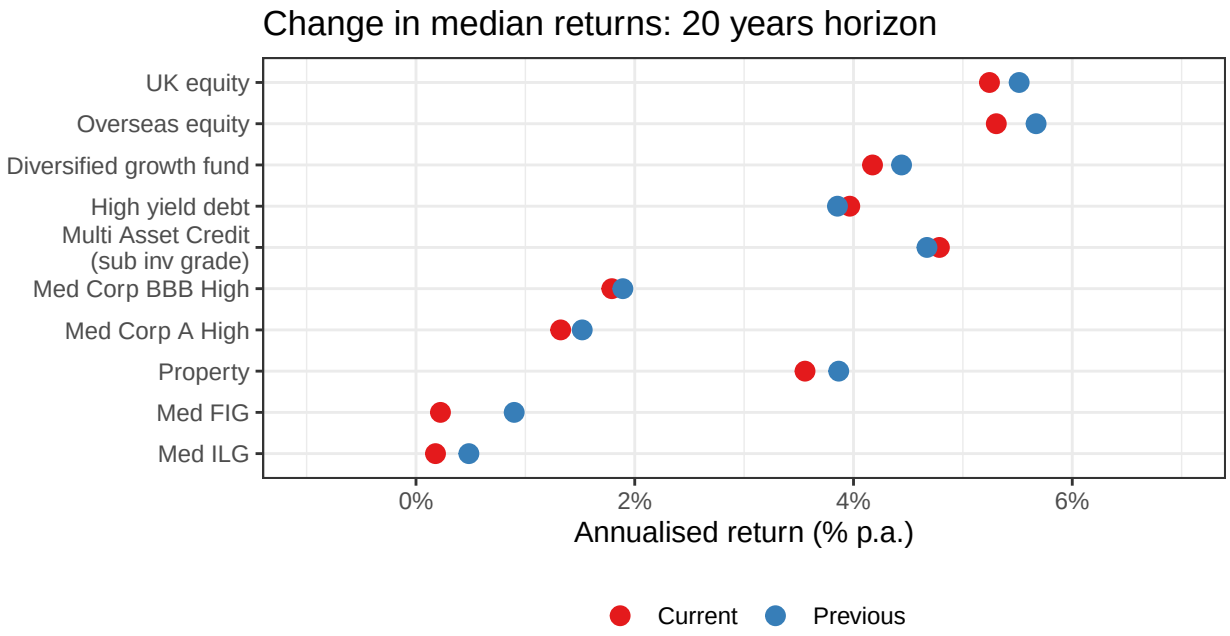
Output summary

Changes in returns and volatilities: December 2019 to March 2020

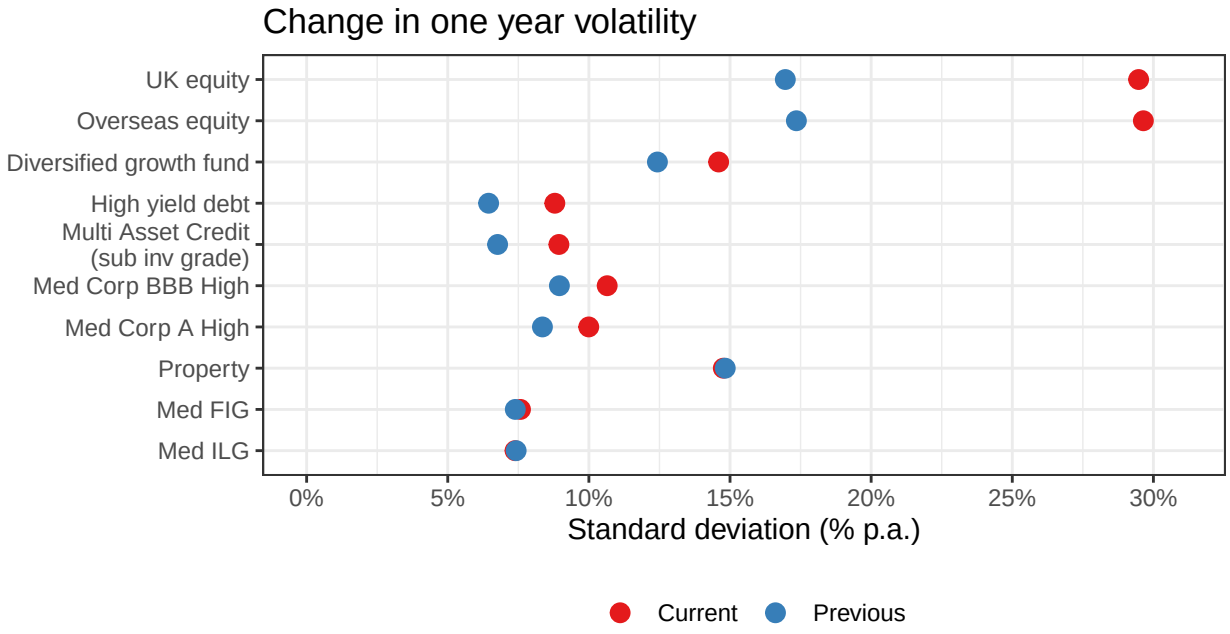
These charts highlight movements in median returns and volatilities over the period. Changes are mainly driven by changing market conditions which get captured in our monthly *minor* calibration process. A full summary of returns at the latest calibration date is included in the Appendix 1.







1 year standard deviations



Interpreting movements in summary statistics over the interval

The main driver of changes in returns over the interval is movements in nominal yield curves and credit spreads. The reason for this is that in the ESS asset returns are generally defined in terms of the risk-free (cash) interest rate plus a risk premium; the assumptions underpinning the size of the risk premium are subjectively chosen and are updated on a less frequent basis during major calibration exercises, and so it is

changes in yield curves[2] that mainly affect return levels as we move from one minor calibration to the next.

Equity return volatilties will change from month to month, in line with changes in the level of at-the-money equity-implied volatility which is used to set the initial level of return volatility in our equity models. The pace of mean reversion in equity volatility is quite fast, meaning that movements in implied-volatility will significantly influence short-term return volatility; longer-term return volatility will be much less affected by changes in the level of impied-volatility observed in the market.

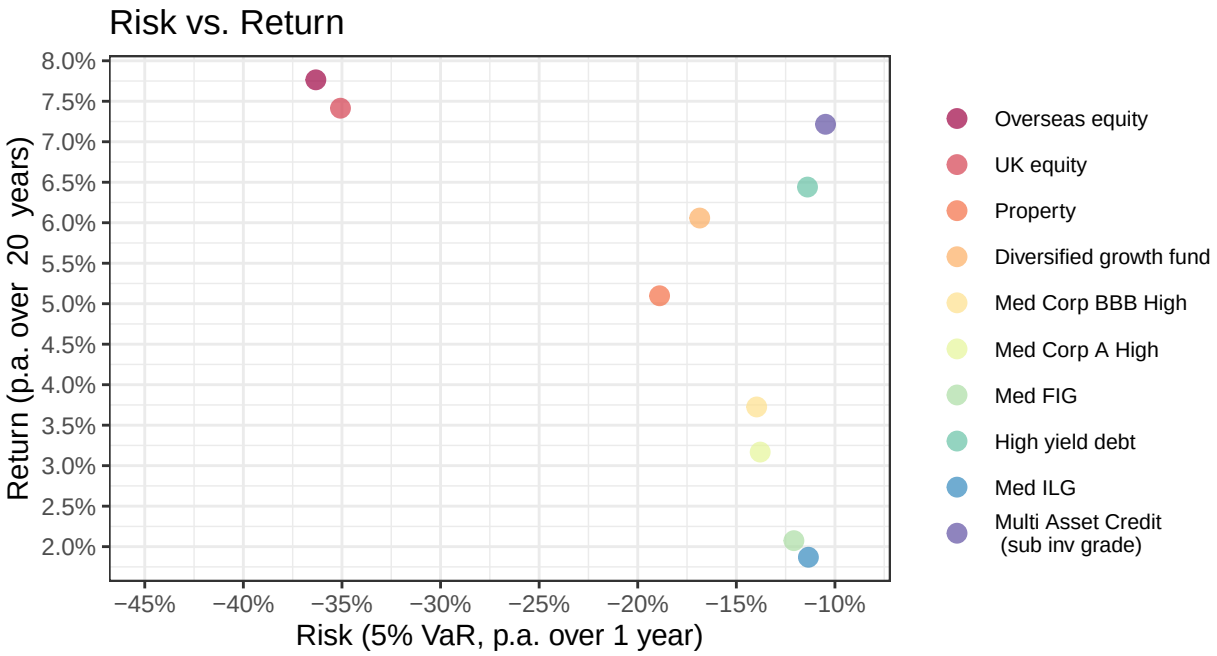
Current ESS outputs

In this section we present a selection of outputs from the different models in the ESS, calculated using the March 2020 calibration.

Risk & return

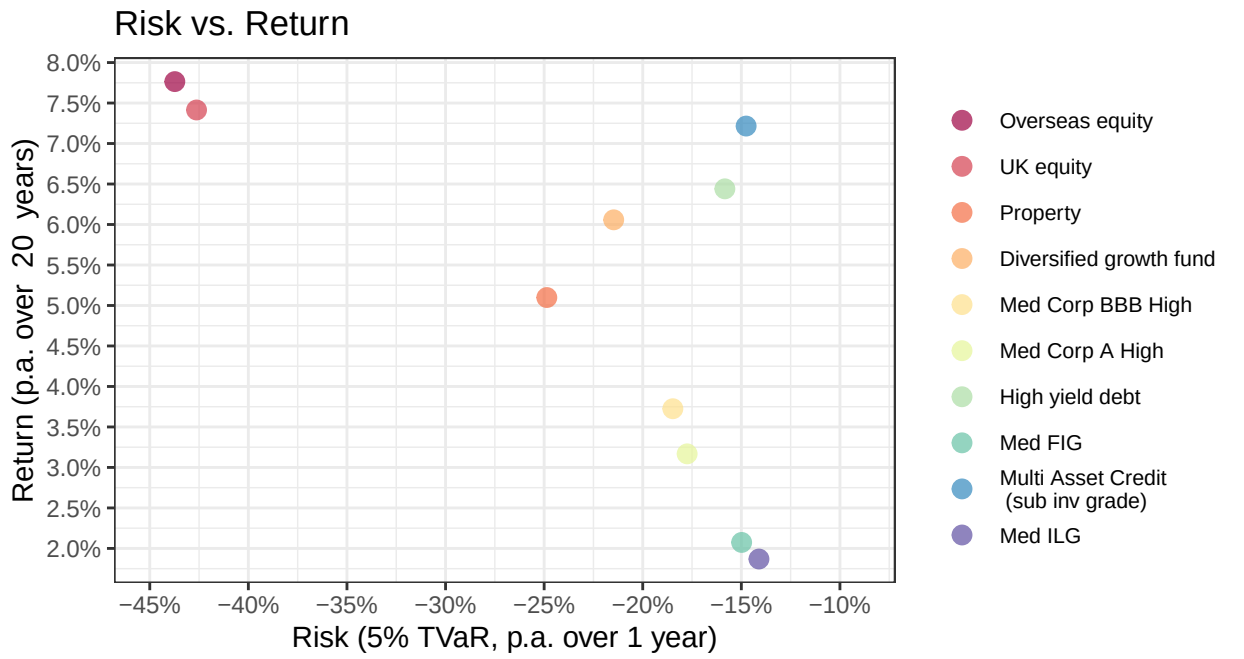
These charts present the risk and return characteristics of the ESS asset classes. We produce two versions using different a risk metric in each case; one uses the Value at Risk (VaR) over 1 year at the 5th percentile level, while the other uses the Tail VaR (i.e. *expected shortfall*) metric over the same horizon and at the same confidence level as the VaR measure. Median returns are evaluated over a 20 year horizon.

Median vs. VaR (1 year @ 5th Percentile)



Median vs. TailVaR (1 year @ 5th Percentile)

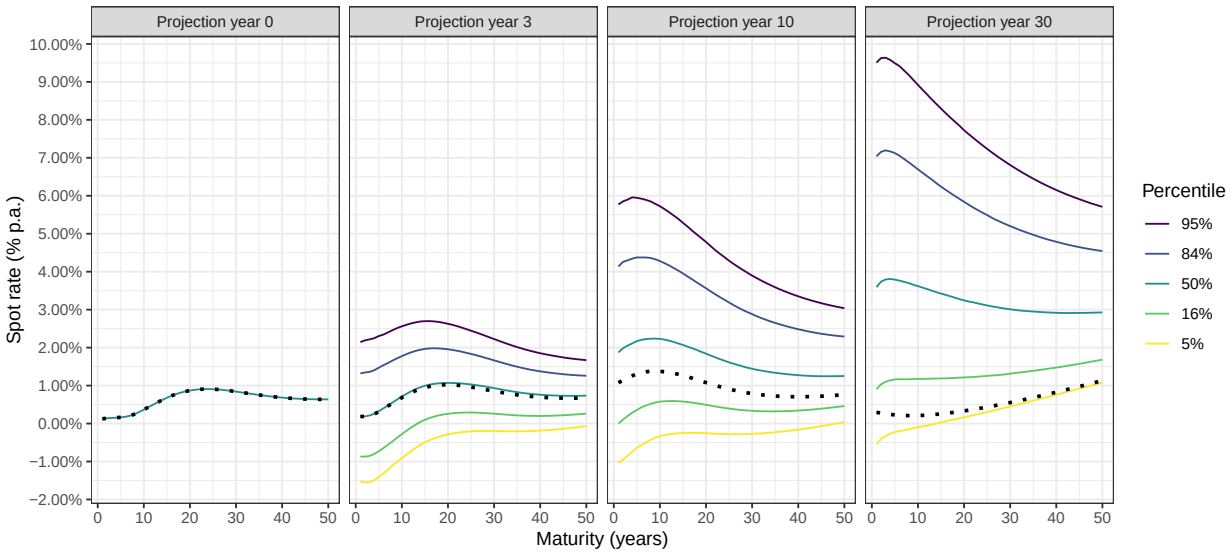
[2]The shape and level of the nominal yield curve determines the expected path that cash rates take over the earlier projection years in the ESS.



Nominal interest rates

We plot below the evolution of the spot rate percentiles across maturity, at different projection horizons. Observe that the spot rates begin at the current yield curve at the outset and as the projection horizon increases, the spot rate percentiles drift upwards; this phenomenon is what we refer to as *yield normalisation*. The market-implied spot curve[3] at each projection horizon is represented by the black dotted line.

Please note that the percentiles that appear in each chart are **not** single yield curves and should not be interpreted as such.

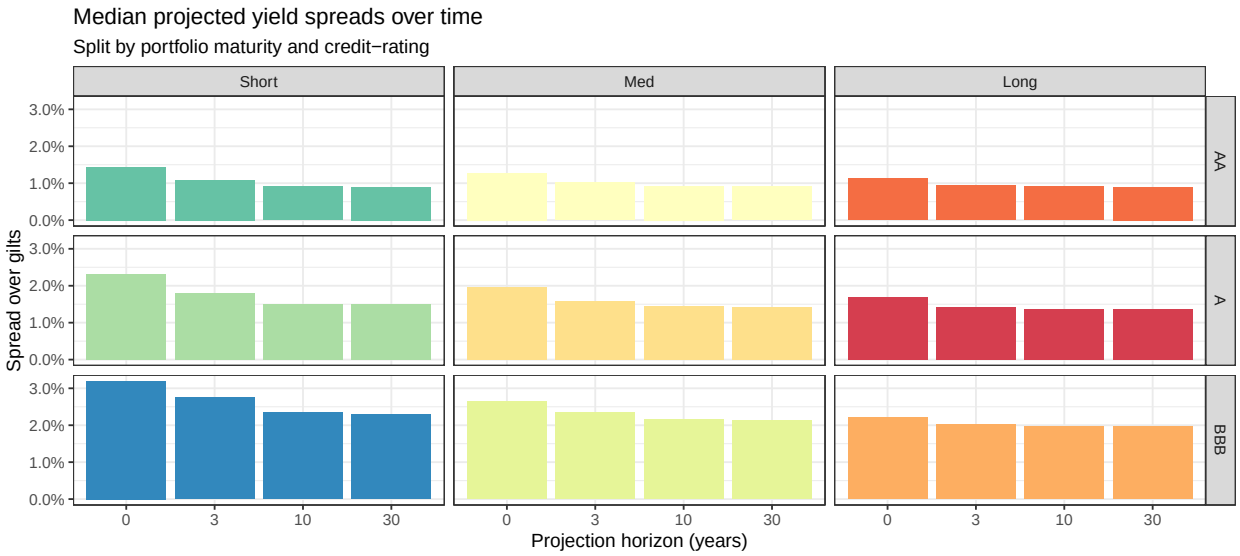


[3]I.e. the spot curve that is implied by the forward rates associated with the observed yield curve at the outset of the projection.

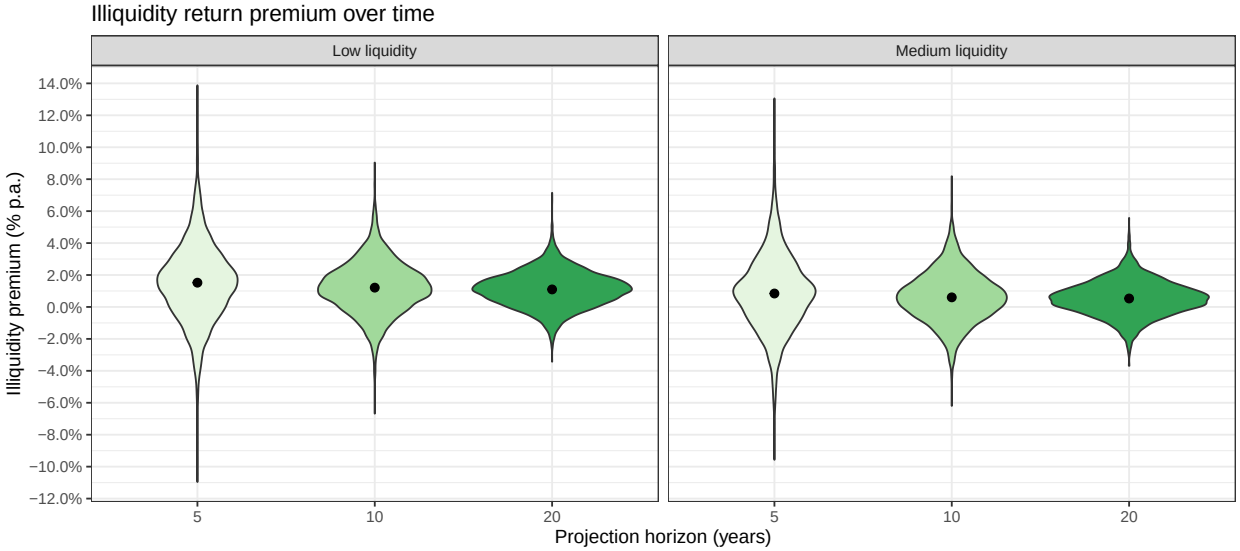
Credit

In this section we present some key summary statistics associated with a selection of credit portfolios modelled within the ESS.

This chart illustrates how yield spreads evolve over time in the credit model for portfolios with different maturities[4] and credit ratings. Portfolios are annually rebalanced to maintain their maturity throughout the projection. Yield spreads are calculated relative to the yield on a portfolio of fixed-interest government bonds of the same maturity as the credit-risky portfolio.



The chart below displays the illiquidity return premium associated with holding an illiquid portfolio of credit-risky bonds in the ESS. The premium is calculated by comparing simulated returns against returns from a liquid portfolio of equivalent maturity and credit rating. Note that the excess returns shown here are associated with a regularly rebalanced portfolio of illiquid assets.

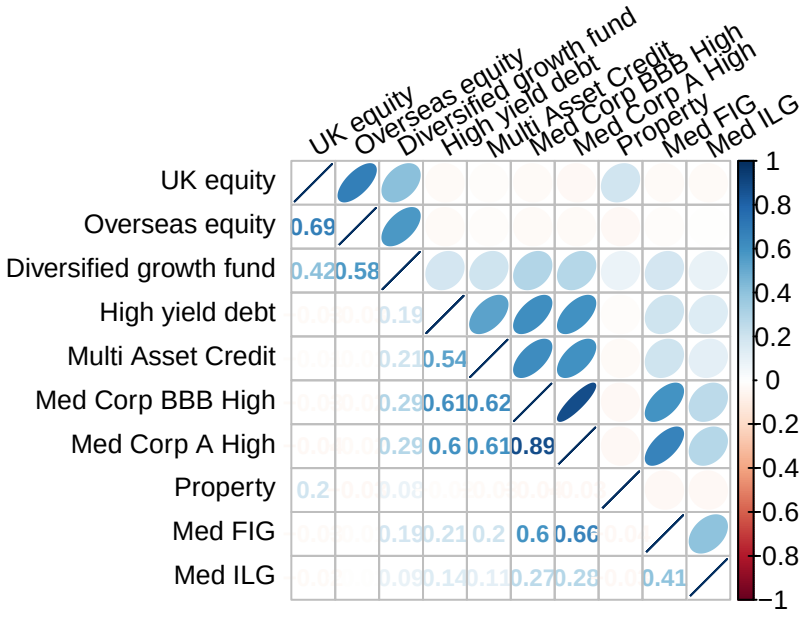


[4]We model bond portfolios with the following maturities: ultra-short, short, medium, and long maturity portfolios have maturities of 2, 4, 14, and 24 years respectively.

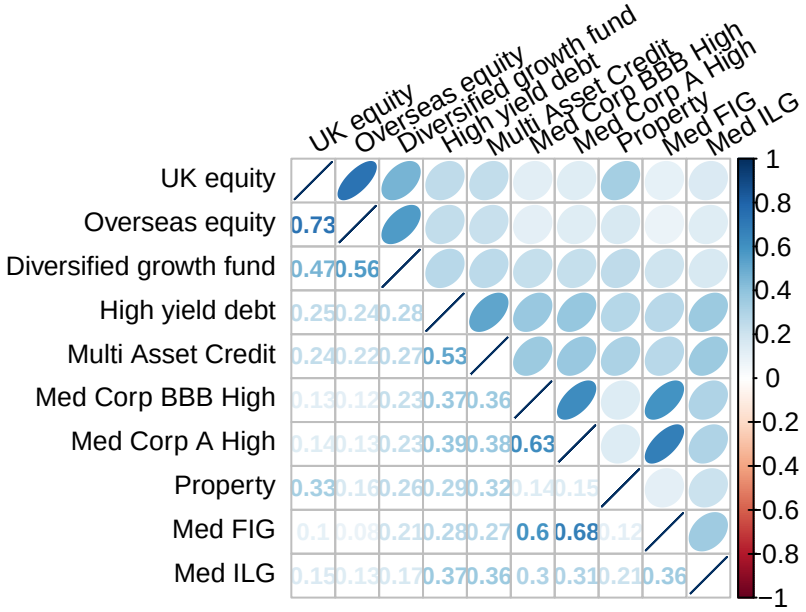
Correlations

Below we present the return correlations between annualised returns over a 1-year and 20-year horizon[5].

1 year annualised returns



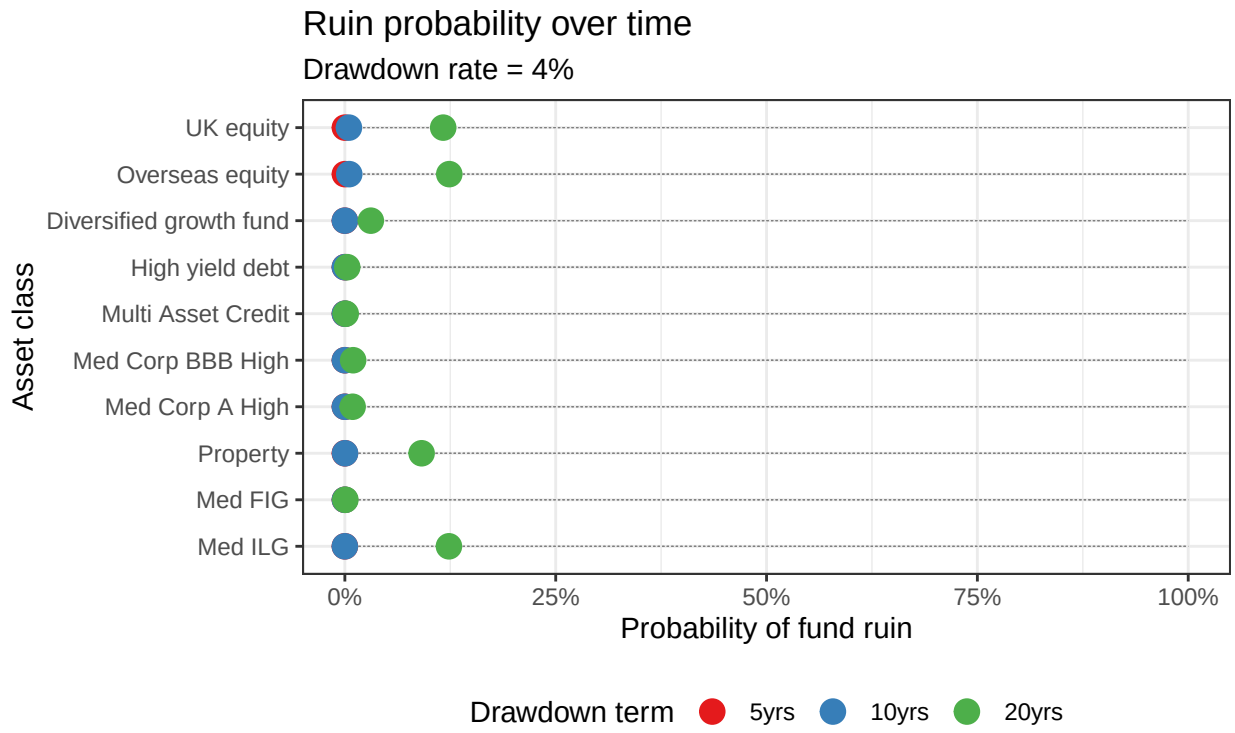
20 year annualised returns



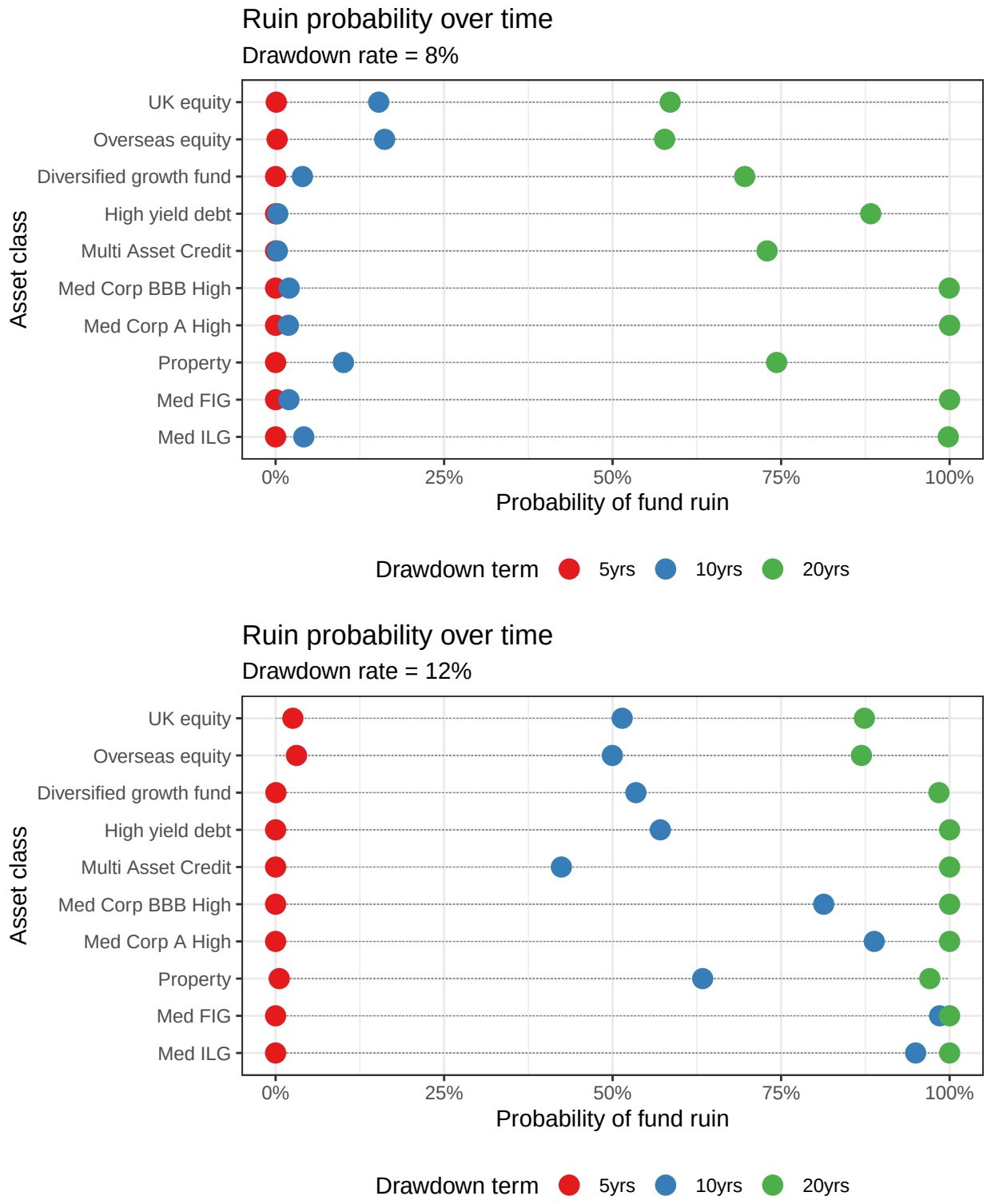
[5]FIG and ILG are abbreviations for fixed-interest gilts and index-linked gilts respectively.

Risk characteristics: A drawdown perspective

In this section we present measures of asset class risk relative to an objective of drawing down a regular, fixed level of income over a number of years. Assuming a fixed rate of the initial fund is withdrawn each year, each chart below plots the probability of fund ruin[6] over different drawdown terms, and for each ESS asset class in which the fund is assumed to be invested.



[6]Meaning the time at which the fund value hits zero.



ESS framework

At its core the ESS is a collection of stochastic models, each of which represent a particular variable of interest. For example, one model generates simulated nominal interest rate scenarios, while another model is

responsible for generating simulated UK equity returns. These models are interrelated in several ways:

- The output from some models serve as inputs to other models within the ESS. For example, the nominal interest rate scenarios feed into the equity models, which generate returns in the form of:

$$\text{simulated equity return} = \text{risk-free cash rate} + \text{equity risk premium}$$

- The randomly generated samples from one model can be correlated with the outputs from another model, e.g. credit spreads associated with different ratings are positively correlated to reflect systemic risks which affect issuers across the market.

Calibrating the ESS models

Model calibration is the process by which our models are parameterised so as to generate realistic dynamics. Our calibration approach involves combining three sources of information:

1. **Market data** (current and historical) which is useful for understanding how returns and other variables have behaved in the past (and therefore provide some information about how they might behave in future);
2. **Economic theory** which helps frame the historical data, providing a guide to the range of plausible outputs we might want our model to generate. E.g. we would want to avoid generating nominal interest rates that are significantly below zero, on the basis that lenders would rather hold cash than lend at substantially negative rates;
3. **Expert judgement** is also needed because the past isn't always like the future, and in some cases there is very little objective information to rely on. One such example is the level to which we expect risk-free interest rates to tend over very long time horizons; there is a paucity of traded instruments at ultra-long maturities to guide this decision and so we incorporate market views from central banks, asset managers, etc. when forming these assumptions.

There are two types of calibration that the ESS Team undertakes:

- **Major calibration**: Major calibrations take place roughly once per year and are used as an opportunity to assess the appropriateness of the choice of models used in the ESS, and whether the longer-term, subjective aspects of the calibration (i.e. source 3 above) are still appropriate. Please see Appendix 2 for a more detailed description of the aspects of the models that are considered during major calibrations. A selection of subjective assumptions currently embedded within the ESS's output are presented in the table below:[7]

ESS output	Target value
Nominal short/long rate short-term expectation	As implied by initial yield curve
Nominal short rate long-term expectation	3.6% p.a.
Nominal long rate long-term expectation	3.6% p.a.
Real short/long rate short-term expectation	As implied by initial yield curve
Real short rate long-term expectation	0.8% p.a.
Real long rate long-term expectation	0.3% p.a.
Equity risk premium	3.6% p.a.
Default recovery rate	35.0%

- **Minor calibrations**: More frequent than major calibrations and involve refreshing the model calibration to allow for updated market conditions like movements in yield curves and equity implied-volatility. These adjustments to the model calibration ensure that the starting point for our simulations matches

[7] *As implied by initial yield curve* means that the target is derived from market conditions; for real and nominal interest rates, this means the expected path of interest rates over the short term is determined by the shape of the market yield curve at the outset of the projection.

observed conditions in the markets. The more subjective elements of the calibration (e.g. long term interest rate targets) are typically not adjusted during minor calibrations. Short term equity volatility, initial credit spreads, and initial yield curves are the main variables that often change from month to month.

Governance and compliance

The ESS is used across virtually all Hymans Robertson's institutional investment clients (representing over 200 investment and actuarial clients) as well as underpinning the GO (Guided Outcomes) offering and the risk models embedded in the APIs used by some asset managers.

The model is supported within the wider Insights & Analytics team of over 100 people, with a dedicated team of 8 people comprising actuaries, financial economic experts, architects and developers. The model was originally developed in 2000 and has been maintained and used continuously since then. It was extensively redeveloped in a major overhaul lasting 2 years from 2014 in order to accommodate a wider set of asset classes and improve performance. The use of the model to support actuarial and regulated advice means the ESS and output from it are subject to scrutiny by many professionals, both internal to Hymans Robertson and third party, as well as regulators.

The model and its calibration are governed and documented in accordance with our professional actuarial requirements (Institute and Faculty of Actuaries) and the requirement to provide fair customer treatment. To support the governance is an ESS Consultation Group. This is an internal group of senior people from around the business who represent their respective areas and have an active interest in the ESS. The objective of this group is to support any changes which relate to the ESS aside from the monthly major calibrations or bespoke client calibrations.

The group is responsible in the major calibration for:

- Reviewing the proposed changes to ensure that they are:
  - aligned to the needs and strategy of the business;
  - high priority;
  - proportionate and reasonable in their technical approach; and
  - able to be implemented in appropriate timeframes.
- Providing technical expertise and challenge to specific changes (this may include proposing alternative changes).
- Ensuring that any impact on existing clients are considered as part of the proposed changes (this includes any assessment of the changes on contractual obligations).
- Ensuring that any impact on consuming systems or tools of the ESS have been considered as part of the proposed changes.
- Reviewing any documentation to support the changes.
- Helping communicate the changes to their respective areas of the business.

The group fits into the following framework for major calibrations:

- ESS Team produces calibration plan setting out the proposed changes based on judgements of market need, professional responsibility and economic developments;
- ESS Consultation Group meets to discuss the plan – this stage gives other stakeholders an opportunity to challenge and influence the priorities for the calibration;
- Once priorities have been agreed, the ESS Team will prepare a final calibration plan, breaking down each high-level objective into smaller chunks and assigning responsibilities for achieving those objectives to different team members;
- The owner of each objective drafts a detailed description (mathematical description where appropriate) of the steps involved in achieving their objective;
- Each objective owner presents the detailed description of their calibration objective to the ESS Team for discussion and review;
- Begin work on the calibration.

- At the end significant documentation is produced along with impact assessments and training sessions given.

The model is calibrated monthly to the market with an annual review of its structure and long term features. The standard monthly run consists of 5,000 projections of up to 100 years at monthly time steps are available across over 70 financial instruments including various forms of equity, property, bonds and credit instruments. Bespoke funds, portfolios and further individual instruments can be modelled within the same environment if required.

The granular nature of the projections enables detailed risk metrics to be calculated for any strategic asset allocations and rebalancing mechanisms. In particular, the use of scenarios rather than just summary statistics (such as volatility, average returns or single correlation assumptions) means that risks about adverse outcomes can be measured directly and accurately.

Appendix 1

A selection of summary statistics associated with a subset of the ESS asset classes are presented below. Returns correspond to annualised cumulative returns; *dispersion* refers to standard deviation of returns over the first projection year.

Risk statistics

	After 1 year		
	Dispersion (% p.a.)	**TailVar (% p.a.) @ 5 pctle**	**Probability of negative returns**
UK equity	29.5%	-42.6%	43.6%
Overseas equity	29.6%	-43.7%	42.8%
Diversified growth fund	14.6%	-21.5%	37.7%
High yield debt	8.8%	-15.8%	28.7%
Multi Asset Credit	8.9%	-14.8%	24.5%
Med Corp BBB High	10.6%	-18.5%	39.8%
Med Corp A High	10.0%	-17.7%	40.9%
Property	14.8%	-24.9%	43.4%
Med FIG	7.6%	-15.0%	50.9%
Med ILG	7.4%	-14.1%	49.8%

Returns after 5 year(s)	**Annualised return percentiles (% p.a.)**						
	1%	**5%**	**16%**	**50%**	**84%**	**95%**	**99%**
UK equity	-16.5%	-11.0%	-5.3%	3.7%	13.6%	20.1%	26.4%
Overseas equity	-17.0%	-11.5%	-5.2%	3.9%	13.4%	19.9%	26.8%
Diversified growth fund	-8.9%	-5.4%	-1.9%	3.6%	9.3%	13.1%	17.2%
High yield debt	-5.2%	-2.3%	0.2%	3.6%	6.3%	7.7%	9.1%
Multi Asset Credit	-4.4%	-1.3%	1.2%	4.5%	7.3%	8.9%	10.1%
Med Corp BBB High	-7.3%	-4.5%	-1.9%	1.8%	5.3%	7.5%	9.9%
Med Corp A High	-7.1%	-4.2%	-2.1%	1.3%	4.5%	6.6%	8.5%
Property	-13.0%	-8.2%	-3.7%	2.1%	8.7%	13.8%	20.9%
Med FIG	-6.6%	-4.7%	-2.9%	-0.3%	2.5%	4.3%	6.3%
Med ILG	-6.7%	-4.9%	-3.0%	-0.0%	3.0%	5.1%	7.2%

Returns after 10 year(s)	Annualised return percentiles (% p.a.)						
	1%	5%	16%	50%	84%	95%	99%
UK equity	-10.4%	-6.3%	-2.1%	4.3%	10.7%	15.2%	19.7%
Overseas equity	-10.3%	-6.4%	-2.1%	4.3%	10.5%	15.0%	19.2%
Diversified growth fund	-5.4%	-2.7%	-0.3%	3.4%	7.3%	10.0%	13.0%
High yield debt	-2.3%	-0.6%	1.0%	3.2%	5.0%	6.1%	7.4%
Multi Asset Credit	-1.7%	0.3%	1.8%	4.0%	5.9%	7.1%	8.2%
Med Corp BBB High	-4.0%	-2.3%	-0.8%	1.3%	3.2%	4.4%	5.5%
Med Corp A High	-3.8%	-2.4%	-1.1%	0.8%	2.6%	3.6%	4.8%
Property	-8.1%	-4.8%	-1.8%	2.5%	7.2%	10.8%	14.6%
Med FIG	-3.9%	-3.0%	-2.0%	-0.5%	1.0%	1.9%	2.9%
Med ILG	-5.2%	-3.8%	-2.5%	-0.4%	1.8%	3.3%	4.8%

Returns after 20 year(s)	Annualised return percentiles (% p.a.)						
	1%	5%	16%	50%	84%	95%	99%
UK equity	-5.2%	-2.3%	0.6%	5.2%	9.9%	13.0%	16.3%
Overseas equity	-5.5%	-2.4%	0.8%	5.3%	10.0%	13.0%	16.2%
Diversified growth fund	-2.1%	-0.3%	1.4%	4.2%	7.1%	8.9%	10.9%
High yield debt	-0.2%	1.0%	2.2%	4.0%	5.7%	6.9%	8.3%
Multi Asset Credit	0.4%	1.9%	3.0%	4.8%	6.5%	7.7%	9.3%
Med Corp BBB High	-1.2%	-0.4%	0.6%	1.8%	3.0%	3.7%	4.4%
Med Corp A High	-1.3%	-0.5%	0.2%	1.3%	2.4%	3.1%	3.8%
Property	-4.0%	-2.0%	0.2%	3.6%	7.4%	9.8%	12.7%
Med FIG	-1.6%	-1.1%	-0.6%	0.2%	1.0%	1.5%	2.0%
Med ILG	-3.7%	-2.6%	-1.5%	0.2%	1.9%	3.2%	4.5%

Appendix 2

In a major calibration we review:

- The parameters that are subjectively chosen (e.g. the ERP), through:
  - Checking on new empirical evidence or studies undertaken by academic researchers;
  - Consulting with our colleagues who set capital market assumptions for our investment practice;
  - Views taken based on other sources, e.g. investment manager publications or views.
- The models themselves, i.e. the particular equations that are used.
  - For example, several years ago, we changed the equations used for modelling interest rates to allow for negative interest rates after these were observed.
- Whether new models for new asset classes are needed.
- The sources that we use for undertaking the monthly minor calibrations:
  - We check that they are still relevant and contain the correct information.