

Under Solvency II firms are required to put money aside so that if a (multiple) extreme (the standard is a 1 in 200) event(s) occur they don't have to declare bankruptcy. In this case therefore risk factors are anything that is likely to affect AVIVA's balance sheet. The point of the challenge is to find a way to robustly calculate correlations between these factors.

### **Risk Factors:**

For this discussion I have referred to the following:

- Surveys conducted by LCP and PWC which assess the capital model of participating insurers under solvency II, one of the participants in both surveys was Aviva. Solvency II sets out regulatory requirements for insurance firms and groups, covering financial resources, governance and accountability, risk assessment and management, supervision, reporting and public disclosure.
- A Cambridge document assessing the overall performance of Solvency II

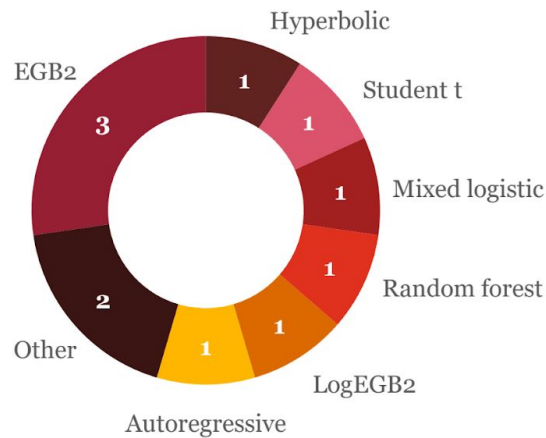
### **PWC Document**

- **Pension Scheme Risk:**
  - Where pension schemes are valued on the Solvency II balance sheet under IAS19, insurers use the **yield on high-quality corporate bonds** for the valuation of the liabilities. **This may differ from the yield on assets actually held by the scheme.**
    - So the yield on high-quality corporate bonds is a risk factor.
  - For most participants, the pension scheme is exposed to a narrowing of **credit spreads**, while all participants indicated that their long-term business is exposed to a widening of credit spreads.
    - When credit spread is talked about, it refers to the difference in yield between, for example, the yield on a high quality corporate bond and the value on the pension. This is an important note as both should have the same maturity date and the bond is chosen carefully under the notation that it will have the same yield as the pension scheme. However, the risk comes in if the yield between the two differs to an extent such that the pension scheme under performs which results in a cost/loss to the insurer.
- **Equity release mortgages**
  - **Illiquid unrated assets such as equity release mortgages (ERM) have been increasingly used by life insurers with large annuity books in recent years to optimise their capital position under Solvency II. As of July 2017 it was noted that 25% of annuity liabilities were backed by illiquid direct investment assets with the Prudential Regulation Authority (PRA) expecting this to increase to 40% by 2020. This illiquid asset category is growing quickly.**

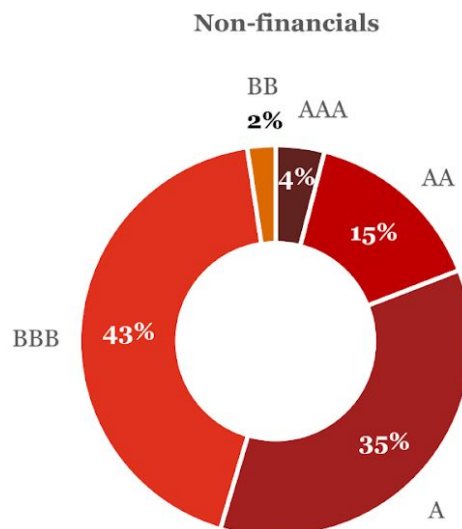
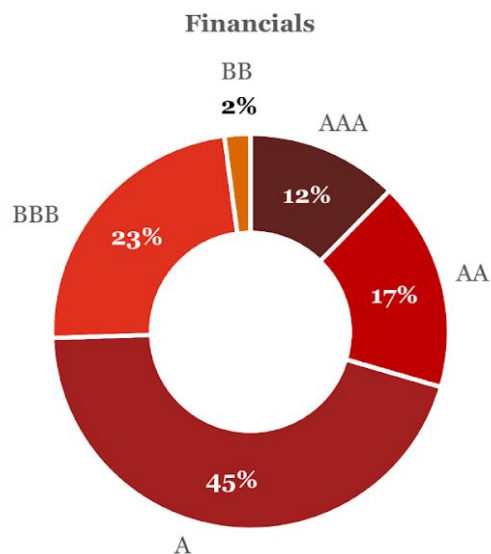
- An annuity is a type of retirement income product that you buy with some or all of your pension pot. It pays a regular retirement income either for life or for a set period.
- As such, we can define, from the perspective of Aviva, annuity liabilities are the amount that is owed to their customers
- Thus, the risk here is that if illiquid and unrated assets, such as ERM's, are used to purchase these annuities the insurer may find it difficult to liquidate and actually recover the full value therefore leading towards losses.
- I am not sure what data we would need for this however.
- **Property growth**
  - Participants model the best estimate property growth assumption in one of two ways – either using a **risk-free rate** or as a **margin over Retail Price Index(RPI)** or the **RPI swap** curve, with the margin ranging from 0.5% to 2%. **Those using a risk-free rate apply a stress in line with the interest rate calibration. The other participants apply a reduction to the assumed best estimate growth rate, ranging between about 1.25% p.a. and 2.60% p.a. .**
    - In short, we need to model inflation
    - Those using the risk free rate that will be stressed in line with interest rates, I believe it means that we need to model the interest rate under macroeconomic factors. So I think we need to generate forecasts for the dynamic paths of macroeconomic factors such as GDP, money rates, and government yields under different scenarios. Along with those for the interest rates we can estimate them jointly in a vector autoregressive system.

## Market risk

- **Credit spread** Solvency II defines spread risk as the risk arising from the sensitivity of the values of assets, liabilities and financial instruments to changes in the level or in the volatility of credit spreads over the risk-free interest rate term structure.
  - The majority of participants model credit spread risk separately to transition and default risk. The average 1-in-200 increase in spread for a 10-year A-rated financial bond (403bps) has increased by 25bps (2017: 378bps).
  - The average 1-in-200 increase in spread for a 10-year A-rated non-financial bond (264bps) has increased by 17bps (2017: 247bps).
- **Distribution of modelling methodology used by survey participants to calibrate credit spread stresses.(graph 1)**



- **Average exposure to financial and non-financial corporate bonds(graph2)**



- **Interest**

- All participants now make an allowance for interest rates to fall below 0% in their internal model.
  - For the first time, all participants indicated that they make an allowance for interest rates to fall below 0% in their interest rate stress calibration. Nearly half of participants apply a floor, with a variety of approaches to implementing this in practice, including a fixed floor, a shifted log-normal model or a floor based on the largest historical negative rates observed.

Where a floor is not applied, most participants observe negative interest rate scenarios at the medium and long term within their models.

- **Currency**

- Solvency II defines currency risk as that arising from the sensitivity of the values of assets, liabilities and financial instruments to changes in the level or in the volatility of currency exchange rates.

## **Life Insurance Risk.**

- **Longevity**

- Longevity risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of **mortality rates**, where a **decrease in the mortality rates leads to an increase in the value of the insurance liabilities. Longevity risk affects contracts where benefits depend on the likelihood of survival**
- participants use external data from the Office for National Statistics (ONS) when calibrating longevity trend stresses. This is as expected, since identifying trends over long time scales requires significantly more data than is needed when assessing base assumptions and so generally cannot be based completely on analysis of an insurer's own available data.
- common risk factor used by participants is gender; age, product or socio-economic group are also used by some participants.
- majority of participants fit a Normal distribution for longevity base stress calculation.

- **Persistency**

- Persistency risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level or volatility of the rates of policy lapses, terminations, renewals and surrenders.
  - The term lapse refers to a "lapse in coverage", meaning the life insurance contract will no longer pay a death benefit or provide any insurance coverage for the insured person. This usually occurs when clients stop paying premiums.
    - This is an issue because insurers forecast out their predicted income (premiums), so if policyholders stop paying sooner than expected it will have a negative effect on income.
  - A surrender is a full cancellation of a life insurance policy.
    - When a policy is surrendered, it does not merely cease premium payments, it also releases all the saved value to the client
    - As such this is therefore an unexpected and early return of value to a client.
    - Typically insurance firms invest these funds and so withdrawing them early may force the company to make a loss on an investment.

- The average persistency level stress selected by participants is 41.3% for non-linked term assurances, 49.7% for unit-linked pensions and 49.9% for with-profits pensions. The average mass lapse stress selected by participants is 24.7% for non-linked term assurances, 27.8% for individual unit-linked pensions and 30.0% for group unit-linked pensions.
- **Mortality**
  - Mortality risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of mortality rates, where an increase in the mortality rate leads to an increase in the value of insurance liabilities. It affects predominantly protection contracts, such as term assurance.
- **Morbidity**
  - Morbidity risk, as defined by Solvency II, is the risk of loss, or of adverse change in the value of insurance liabilities, resulting from changes in the level, trend or volatility of disability, sickness and morbidity rates. It affects predominantly health contracts such as critical illness insurance and income protection.

#### Important Results for document

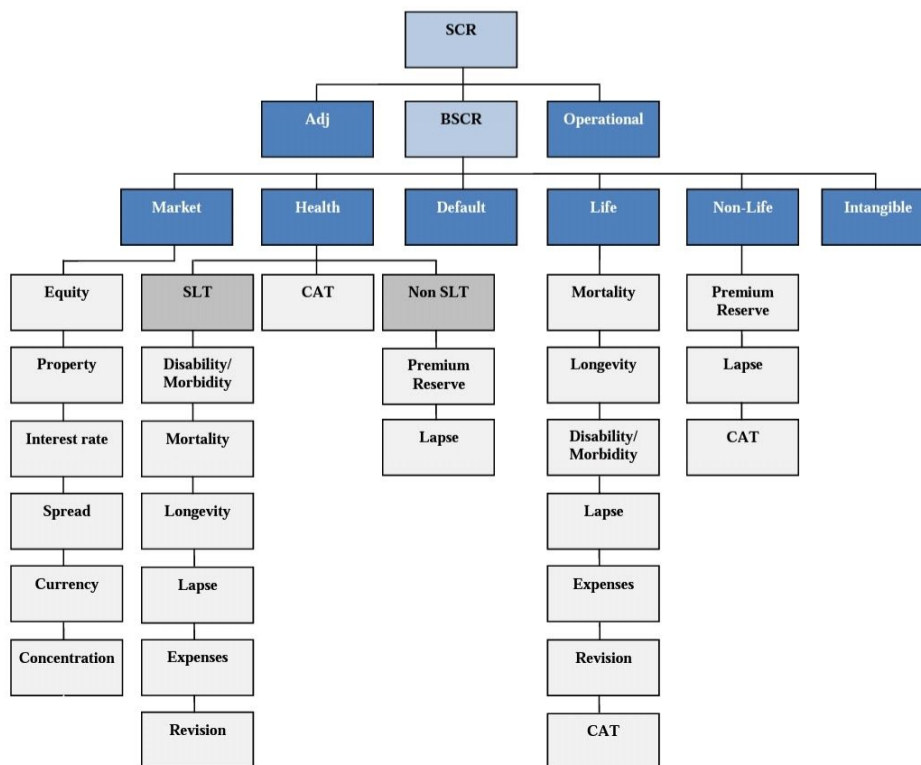
Dependency between risks	
High	100%–67%
Medium	66%–34%
Low	33%–1%
Nil	0%

- The majority of participants continue to assume zero dependency between longevity trend and persistency level risks, with the remainder assuming a low positive dependency.
- Participants are broadly split in assuming zero or low positive correlation between mortality and persistency, while a clear majority assumed independence last year .
- all participants for which it is relevant assume a medium or high positive correlation between credit spread and equity risks. The assumptions are broadly consistent with the Standard Formula's prescribed high positive correlation (+75%).
- Dependency assumptions between other pairs of market risks
  - Between credit spreads and interest rate level, dependencies range from zero to medium positive, with most participants using a low positive correlation.

- Between equity and interest rate level, dependencies range from low negative to medium positive, with the highest proportion of participants using a low positive assumption.
- Dependencies between property and other market risks are typically medium positive (with credit spreads and with equity) or low positive (with interest rate level).
- participants assume either low positive or zero dependency between longevity and credit risks, and the majority of participants assume low positive correlation between persistency and credit risks.

### End of PWC paper

Possible example of a flow chart demonstrating the risk factors associated with each product (graph 3)



### Cambridge paper

<https://www.cambridge.org/core/journals/british-actuarial-journal/article/review-of-solvency-ii-has-it-met-its-objectives/20A2199009FF6FF7F6445E411328D313/core-reader>

Solvency II methodology makes no allowance for the combined impacts of risks. This can operate either to increase or decrease overall capital required: e.g., the combined impact of a

mass lapse stress with most other stresses would result in an overall reduction in required capital compared with both considered separately; on the other hand, for an insurer subject to guaranteed annuity options, the combined impact of an interest rate down stress and a longevity stress is likely to be higher than with both considered separately.

In the United Kingdom, annuity business is the most important long-term guaranteed business written, and it has been recognised that default risk rather than spread risk was key and this was accommodated through a higher discount rate linked to the assets' owned and lower capital requirements.

## **LCP PAPER**

<https://insight.lcp.uk.com/acton/attachment/20628/f-121c7fa2-93e9-49d6-95bd-c20c8b044d35/1/-/-/-/-/LCP%20Solvency%20II%20report%202019.pdf?sid=TV2:06e3aBltJ>

Non-life underwriting risk continues to be the greatest risk for the insurers with around two-thirds identifying it as such. The next most material risk is market risk with around 16% of insurers analysed identifying it as their greatest risk.

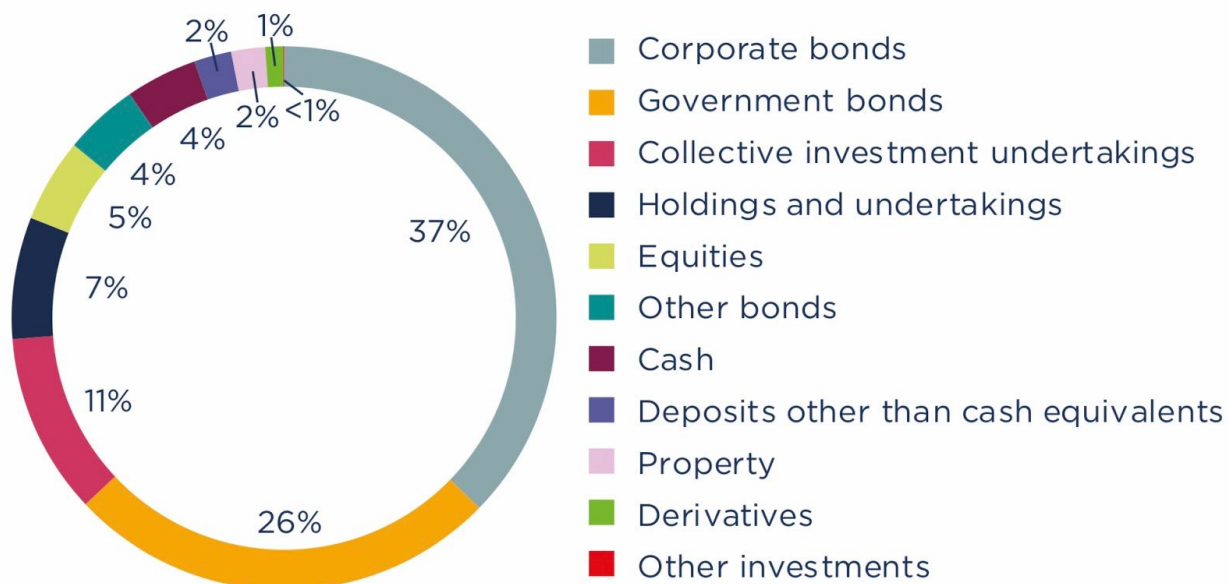
Five insurers had a change in their most material risk between 2017 and 2018:

- Aviva's most material risk changed from market to non-life underwriting. This followed a slight reduction in the level of market risk whilst non-life underwriting risk is broadly unchanged since last year.
  - Non-life indicates general insurance
  - General liability insurers, in aggregate, hold a greater proportion of their investments in government and corporate bonds than property insurers (78% versus 33%). This may reflect the longer-tailed nature of the liabilities of general liability insurers, compared to property insurers, meaning longer duration assets are required.(see graph 5)

Graph 4

The following chart sets out the aggregated allocation across each type of asset

### Aggregate investment holdings



On an aggregate basis, 63% of assets at the 2018 year end were held in either corporate or government bonds. The next largest allocation was 11% held in collective investment undertakings. Collective investment undertakings are pooled funds that allow investors to access a wide range of investments in an efficient way.

Graph 5



**Aggregated investment holdings by firm group**

Firm Group	Number of firms	Corporate bonds	Government bonds	Collective investment undertakings	Holdings in related undertakings	Equities	Other bonds	Cash	Deposits other than cash equivalents	Property	Derivatives	Other investments
Medical expense	11	43%	17%	19%	3%	0%	0%	10%	10%	2%	0%	0%
Income protection	1	38%	17%	0%	0%	0%	0%	15%	20%	0%	0%	0%
Motor (liability and other)	16	54%	17%	14%	2%	2%	0%	5%	5%	2%	0%	0%
Marine, aviation, transport (direct and non-prop RI)	1	54%	28%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Property (direct and non-prop RI)	13	18%	15%	37%	3%	5%	0%	10%	0%	2%	0%	0%
General liability	8	41%	36%	0%	0%	3%	0%	0%	0%	0%	0%	0%
Credit and suretyship	3	42%	22%	20%	0%	2%	0%	0%	0%	0%	0%	0%
Legal expenses	1	24%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Assistance	1	0%	0%	76%	0%	0%	0%	0%	24%	0%	0%	0%
Misc. financial loss	7	53%	19%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Multi	38	35%	30%	10%	10%	5%	0%	0%	0%	0%	0%	0%
All	100	37%	25%	10%	5%	5%	0%	0%	0%	0%	0%	0%

