Subject SP7

CMP Upgrade 2021/22

CMP Upgrade

This CMP Upgrade lists the changes to the Syllabus objectives, Core Reading and the ActEd material since last year that might realistically affect your chance of success in the exam. It is produced so that you can manually amend your 2021 CMP to make it suitable for study for the 2022 exams. It includes replacement pages and additional pages where appropriate.

Alternatively, you can buy a full set of up-to-date Course Notes / CMP at a significantly reduced price if you have previously bought the full-price Course Notes / CMP in this subject. Please see our 2022 *Student Brochure* for more details.

We only accept the current version of assignments for marking, *ie* those published for the sessions leading to the 2022 exams. If you wish to submit your script for marking but have only an old version, then you can order the current assignments free of charge if you have purchased the same assignments in the same subject in a previous year, and have purchased marking for the 2022 session.

This CMP Upgrade contains:

- all significant changes to the Syllabus objectives and Core Reading
- additional changes to the ActEd Course Notes and Assignments that will make them suitable for study for the 2022 exams.

0 Changes to the Syllabus

This section contains all the ***non-trivial*** changes to the syllabus objectives.

Objective 3.4.4 has been reworded as follows:

3.4.4 Describe Mack's model and the ODP model.

A new Objective 3.4.5 has been added as follows:

3.4.5 Describe how to apply bootstrapping to these two models.

Objectives 3.4.5 and 3.4.6 have been renumbered as 3.4.6 and 3.4.7 respectively.

1 Changes to the Core Reading and ActEd text

This section contains all the ***non-trivial*** changes to the Core Reading and ActEd text.

Chapter 2

Section 4.3

The last Core Reading bullet point in the third paragraph on page 24 has been deleted along with the paragraph of ActEd text that follows the bullet point list.

Chapter 3

Section 1

'Employment practices liability (EPL)' has been added to the bullet point list of the main types of liability insurance.

Section 1.1

Under 'Employers' liability' the following sentence of Core Reading has been deleted:

> **Loss of or damage to employees' property is usually also covered.**

The next paragraph of ActEd text has been deleted and the following paragraph of Core Reading now reads as follows:

> **The benefit can be in the form of regular payments to compensate for disabilities that reduce the employee's ability to work and/or lump sum payments to compensate for permanent injuries to the employee.**

A new sub-section of Core Reading on 'Employment practices liability' has been added after the sub-section on 'Directors' and Officers' (D&O) liability' as follows:

Employment practices liability (EPL)

This insurance product is a form of D&O insurance, specifically covering risks relating to employment practices. It indemnifies the company and directors against the liabilities for the legal costs and subsequent awards for defending employment-related claims.

It is more commonly now sold as a standalone product, although for reserving purposes it may continue to be considered alongside D&O insurance, depending on the materiality of the portfolio. The inflationary trends for EPL tend to be different to D&O.

Section 1.2

A new sub-section on 'Employment practices liability' has been added after the sub-section on 'Directors' and Officers' (D&O) liability' as follows:

Employment practices liability

The perils include defending against, and possible settlement costs, of the following:

- **unfair dismissal of an employee**
- **constructive dismissal of an employee**
- **discrimination against an employee, for example resulting in being overlooked for a promotion or paid less for doing an equivalent job**
- **failure to correctly follow misconduct procedures when dismissing an employee**
- failure to comply with working hours legislation
- wrongful demotion.

Section 1.3

A new sub-section on 'Employment practices liability' has been added after the sub-section on 'Directors' and Officers' liability' as follows:

Employment practices liability

EPL is usually written on a claims-made basis.

Section 1.4

On page 14, the sub-section heading on 'Professional indemnity / Directors' and Officers' liability / Cyber' now also includes EPL.

Section 1.6

On page 19 the sub-section heading 'Directors' and Officers' liability' now also includes 'Employment practices liability'.

The following paragraph of Core Reading has also been added to the end of that sub-section:

For EPL policies, it is important also to consider the current legal environment and the industry being covered as this will have a material impact on the claim costs.

Section 3.4

The first sentence of the last paragraph of Core Reading on page 43 now reads as follows:

The exposure measure for payment protection insurance on personal loans is normally the amount of the loan or the total amount payable under the policy.

Section 4.4

The last paragraph of ActEd text has been deleted.

Summary

The summary at the end of the chapter has been updated in light of the above changes.

Chapter 6

Section 2.3

The first sentence of Core Reading now reads as follows:

> **The smaller risks may not be ceded to the reinsurer because they are below the minimum retention.**

Section 3.7

In the first paragraph of Core Reading at the top of page 27, the second sentence now reads as follows:

> **This is in excess of a specified retention, resulting from a catastrophic event.**

Section 7

The material in this section has been reordered to make it clearer that structured finance is a broader term than securitisation. Please use replacement pages 41 to 46 provided at the end of this Upgrade to update your materials accordingly.

Summary

The summary at the end of the chapter has been updated in light of the above changes.

Chapter 7

Section 1.6

The first paragraph of ActEd text has been deleted.

Chapter 8

Section 5.6

The following Core Reading bullet point has been added to the list of other requirements to protect policyholders:

- **Requirement to embed the consideration of the financial risks from climate change in their governance arrangements.**
  - **To ensure management adequately take account of climate risk and the impact it could have on the business.**

Chapter 9

Section 3

A lot of additional material has been added to this section concerning 'climate change'. Please use replacement pages 29 to 40 provided at the end of this Upgrade to update your materials accordingly.

Summary

The summary at the end of the chapter has been updated in light of the above changes.

Chapter 11

Section 1.1

The sub-section on 'Climate change' has been updated. Please use replacement pages 9 to 14b provided at the end of this Upgrade to update your materials accordingly.

Section 3.1

The last paragraph of Core Reading in the sub-section on 'Incomplete and non-existent data' now reads as follows:

> **On these occasions, assumptions will have to be made. These may be based on similar classes of business, benchmark statistics or the modeller's subjective judgement. In any case, inadequate data will lead to uncertainty within the model. It is important to use expert judgement to validate the use of assumptions to correct for data issues.**

Section 3.5

Some of the material in this section has been re-written. Please use replacement pages 25 and 26 provided at the end of this Upgrade to update your materials accordingly.

Chapter 14

Section 8

A new section covering 'Interactions with the claims department' has been added to the end of this Chapter. Please use replacement pages 16a and 16b provided at the end of this Upgrade to update your materials accordingly. The existing Section 8 has been renumbered accordingly.

Solutions to Practice Questions

There have been a number of changes to the solution to Practice Question 14.2. Please use replacement pages 23 to 26 provided at the end of this Upgrade to update your materials accordingly.

Chapter 15

Section 3.4

In the sub-section on 'Berquist-Sherman method' the last paragraph of Core Reading now reads as follows:

> **Practical use of this method is relatively limited as the method requires a lot of additional judgements to be made around the settlement patterns or case strength adequacy.**

The last paragraph of ActEd text in the same sub-section has also been deleted.

Chapter 16

Section 0

At the top of page 3, the first paragraph of Core Reading now reads as follows:

> **The core focus of a reserving exercise is to determine a point estimate of the best estimate reserves. It is important to be able to communicate to the users of actuarial work the uncertainties surrounding the best estimates using a variety of methods, which can include stochastic reserving techniques. Stochastic reserving techniques are commonly used to determine quantitative estimates of the volatility in reserves as an input to capital models.**

Also on page 3, the last paragraph of Core Reading now reads as follows:

> **This chapter includes a number of references to the book 'Hindley, David, Claims Reserving in General Insurance, 2017, Cambridge University Press' (which is available to students through the IFoA website) and two papers produced by the Pragmatic Stochastic Reserving Working Party (PSRWP). The material contained in these does not form part of the Core Reading and is therefore not examinable. References have been included to direct an interested reader to a source of additional information.**

Section 1

On page 5, the penultimate of Core Reading now reads as follows:

> **Communicating the outputs of a stochastic reserving exercise is an important part of the process, as is communicating the limitations, assumptions and materiality of judgements made to derive the estimates.**

Section 3

The first paragraph of Core Reading at the top of page 7 has been replaced by the following two paragraphs of Core Reading:

> **Model error arises because actuarial models are often a simplification of a very complex (and unknown) underlying system and the model being used may not fully reflect all features of the underlying process. An example of this is the chain ladder model, which does not include an allowance for calendar year effects, introducing model error to the process.**

This results in uncertainty in the estimates produced by the model.

Sections 5 and 6

There have been a number of changes to the material in these sections. Please use replacement pages 13 to 18b provided at the end of this Upgrade to update your materials accordingly.

Section 6.4

The following paragraphs of Core Reading have been added to the end of this section:

Further detail for the interested reader can be found in section 6 of the 2016 PSRWP paper.

We note that we can extend the bootstrapping process to incorporate a whole variety of models. An example of an extension is the incorporation of the Mack method which removes the need for all development to be positive. The Mack model is equally easy to implement, using bootstrapping, in a spreadsheet in a similar way to the ODP model.

Section 6.7

The following sentence has been added to the end of the first paragraph of Core Reading:

The key purpose of the method is to produce an estimate of the reserve uncertainty over a one-year time horizon.

Sections 7 to 9

Section 7.1 has been renamed 'Dependencies'.

In addition, there have been a number of changes to the rest of the material in these sections. Please use replacement pages 25 to 32 provided at the end of this Upgrade to update your materials accordingly.

Chapter 17

Section 2.9

The first sentence of the penultimate paragraph of Core Reading now reads as follows:

Where proportional reinsurance is in place, we can review the selected net to gross ratios to ensure these at least allow for the proportional element.

Section 5.2

The first paragraph of Core Reading after the bullet point list on page 21 now reads as follows:

When using a rate index, it is important to understand the inflationary allowance that is included within this and whether inflation needs to be explicitly allowed for beyond the allowance within the rate index. Changes to the types of claims covered and any claim frequency trends should also be considered and allowed for.

Chapter 18

Section 3.3

An extra bullet point has been added to the Core Reading list on page 16 as follows:

- **Climate change. This could make use of the Representative Concentration Pathways ('RCPs'), a set of internationally adopted scenarios that describe alternative pathways for future greenhouse gas emissions.**

Summary

On page 25, 'Climate change' has been added to list of typical scenarios to be tested

Chapter 25

Section 2.2

The definition of the 'Cape Cod method' in the fifth paragraph has been updated in line with the changes to the Glossary outlined below.

Glossary

The following definitions have been amended:

Accumulation of risk

An accumulation of risk occurs when a single event can give rise to claims under several different policies (for example in property insurance), or to claims from many risks covered under the same policy (for example in employers' liability).

Cape Cod method

The Cape Cod method uses the historical experience of some or all origin years as implied by the chain ladder method, adjusted for rate changes and claims inflation. More weight is given to years which the incurred chain ladder method suggests are more developed and where the exposure (usually measured by premium written) is higher.

Stop loss reinsurance

An excess of loss reinsurance that provides protection based on the total claims, from all perils, arising in a class or classes over a period. The excess point and the upper limit are often expressed as a percentage of the cedant's premium income rather than in monetary terms; for example, cover might be for a loss ratio in excess of 110% up to a limit of 140%.

No new definitions have been added and no existing definitions have been removed. There have been no changes to the list of abbreviations.

2 Changes to the X Assignments

Overall

There have been minor changes throughout the assignments.

More significant changes are listed below.

Assignment X2

Question X2.1

This question has been slightly reworded as follows:

> Describe the potential benefits and problems of using industry-wide data for reserving purposes. [4]

Question 2.9

The second paragraph of this question has been slightly reworded as follows:

> Discuss the possible impact of this on the mix of professional indemnity business and suggest how the experience from the two channels might differ. [8]

Assignment X3

Question X3.5

Part (i) of this question has been slightly reworded as follows:

> (i) Define what is meant by a reserve for pure IBNR. [1]

Assignment X4

Question X4.1

This question has been slightly reworded as follows:

> Outline the analyses that should be carried out and other factors an actuary should take into account when analysing the results of a reserving exercise. [4]

Question X4.3

The first sentence of this question has been slightly reworded as follows:

> Define the following terms and describe how each of these elements of uncertainty can be reduced:

Question X4.4

This question has been slightly reworded as follows:

> List reasons for correlations between different lines of business and describe how allowance can be made for dependencies within a stochastic model. [4]

Question X4.8

The last paragraph of part (ii) of this question has been slightly reworded as follows:

> Suggest the rationale behind each approach and outline the advantages and disadvantages of each method. [10]

Assignment X5

Question X5.2

The second sentence of this question has been slightly reworded as follows:

> Describe briefly the methods you could use to determine an appropriate allocation of capital to each of the sub-portfolios of your business. [5]

Assignment X6

Question X6.1

Part (i) of this question has been slightly reworded as follows:

> (i) State a formula that, for a surplus treaty, relates the expected maximum loss (*EML*) to the retention (*r*) and number of lines (*l*). [1]

Question X6.5

Parts (ii) and (iii) of this question have been slightly reworded as follows:

> (ii) Outline the other steps that might be taken to ensure that all valid claims on the company by policyholders are paid, if such claims could not be met in full by the company. [2]
>
> The following proposals have been put forward as part of the review of legislation:
>
> (a) a minimum solvency margin should be proportional to technical reserves
>
> (b) a minimum solvency margin should be proportional to the square root of premium income
>
> (c) there should be a statutory basis for the calculation of technical reserves

(d) all technical reserves plus the minimum solvency margin should be covered by government securities

(e) all reinsurance should be placed with a state owned reinsurance company.

(iii) Suggest possible reasons for each of the five proposals above, and comment on their suitability or otherwise. [15]

3 Other tuition services

In addition to the CMP you might find the following services helpful with your study.

3.1 Study material

We also offer the following study material in Subject SP7:

- Flashcards
- Revision Notes
- ASET (ActEd Solutions with Exam Technique) and Mini-ASET
- Mock Exam and AMP (Additional Mock Pack).

For further details on ActEd's study materials, please refer to the 2022 *Student Brochure*, which is available from the ActEd website at **www.ActEd.co.uk**.

3.2 Tutorials

We offer the following (face-to-face and/or online) tutorials in Subject SP7:

- a set of Regular Tutorials (lasting a total of three days)
- a Block (or Split Block) Tutorial (lasting three full days)
- an Online Classroom.

For further details on ActEd's tutorials, please refer to our latest *Tuition Bulletin*, which is available from the ActEd website at **www.ActEd.co.uk**.

3.3 Marking

You can have your attempts at any of our assignments or mock exams marked by ActEd. When marking your scripts, we aim to provide specific advice to improve your chances of success in the exam and to return your scripts as quickly as possible.

For further details on ActEd's marking services, please refer to the 2022 *Student Brochure*, which is available from the ActEd website at **www.ActEd.co.uk**.

3.4 Feedback on the study material

ActEd is always pleased to receive feedback from students about any aspect of our study programmes. Please let us know if you have any specific comments (*eg* about certain sections of the notes or particular questions) or general suggestions about how we can improve the study material. We will incorporate as many of your suggestions as we can when we update the course material each year.

If you have any comments on this course, please send them by email to **SP7@bpp.com**.

7 Capital market products

7.1 Types of capital market products

In this section we discuss products where risk is transferred to the capital markets rather than insurance markets. We will discuss the following products:

- committed (or contingent) capital
- securitisation and structured finance.

7.2 Committed (or contingent) capital

Committed capital or contingent capital is based on a contractual commitment to provide capital to an insurer after a specific adverse event occurs that causes financial distress. The insurer purchases an option to issue its securities at a predetermined price in the case that the defined situation occurs, on the understanding that the price would be much higher after such an event.

If the defined event occurs, leading to financial distress of the insurer, then the price of the insurer's securities will fall (*ie* it will be more expensive to raise capital by issuing securities). The option will allow the insurer to sell its securities after the adverse event at a higher price than their market price.

For example, if the securities have a current market value of \$100, then the insurer might fix the predetermined price (*ie* the strike price of the option) at \$100. Following the adverse event, the market value of the securities might fall to \$80. However, the insurer will still be able to issue such securities at the higher price of \$100.

There may be one or more triggers that have to occur before the option can be exercised, in order to avoid moral hazard.

Contingent capital provides a mechanism of ensuring that, should a particular risk event happen, capital will be provided. As such, it is a cost-effective method of protecting the capital base of an insurance company. Under such an arrangement, capital would be provided as it was required following a deterioration of experience (*ie* it is provided when it is needed).

7.3 Securitisation and structured finance

You may have met securitisation in an earlier subject.

Purpose of securitisation

Securitisation has two main purposes:

- Risk management – to transfer insurance risk to the banking and capital markets.

  It is often used for managing risks associated with catastrophes, as the financial markets are large and capable of absorbing catastrophe risk.

  It involves turning a risk into a financial security, *eg* as in a catastrophe bond.

- Capital management – to convert illiquid, inadmissible assets into liquid admissible assets, hence improving the balance sheet.

  Almost any assets that generate a reasonably predictable income stream can in theory be used as the basis of a securitisation. Examples of illiquid assets that could be securitised are:

  – future profits, *eg* on a block of in-force insurance policies

  – mortgages (and other loans).

  Each of these could be securitised into tradeable instruments (*eg* bonds), in order to raise capital. The owner of the assets issues bonds to investors (*eg* pension funds, insurance companies and banks) and the future cashflow stream generated by the secured assets is then used to meet the interest and capital payments on the bonds.

  There is typically risk transfer as the repayments on the bonds are made only if, for example, the future profits emerge or mortgage repayments are made.

For example, a portfolio of mortgage loans owned by a bank could be pooled together and the cashflows from these mortgages used to service the interest and capital payments on a bond. Securitisation of this type that had been backed by sub-prime mortgages in the US, was the focus of much attention during the sub-prime crisis and credit crunch.

Operation of securitisation

In simple terms, a securitisation works as follows:

1. An investor purchases a bond from the insurance company and therefore provides a sum of money to the insurer.

2. The repayment of capital (and possibly of interest) is contingent on:

   – a specified event *not* happening, *eg* an earthquake measuring 6.5 on the Richter scale *not* happening, or

   – the portfolio of insurance business (upon which the bond is securitised) producing adequate profits.

3. If the event does happen (*eg* the aforementioned earthquake occurs), or inadequate profits are made from the securitised business, the insurer may default on the interest and capital payments due under the bond:
   - in the case of securitising a particular risk, the insurer can use the sum of money provided from the investor (in purchasing the bond) to cover the cost of claims arising from the earthquake
   - in the case of securitising a block of business, the poor experience of the business has been passed directly to the investor.
4. If the event does not occur or the business makes adequate profits, the investor gets their interest and capital back in the normal way.

In practice, the direct link between the investor and the issuer is broken by a special purpose vehicle (SPV), which is a separate legal entity that sits between the parties. Where it is a portfolio of business that is being securitised, the securitised assets are transferred into this vehicle.

Question

Explain why a special purpose vehicle is used in practice.

Solution

The existence of a separate vehicle with separate ownership of the securitised assets provides better security and greater transparency for investors in the securitisation.

This may seem like a particularly high-risk investment. It is. However, as long as the expected return on the investment is commensurate with the investor's required (risk-adjusted) rate of return, then a market for such an investment will exist.

The rationale is that insurance catastrophe risk or the risk of underperformance of the securitised business, is not correlated with investment market risks and so there is a benefit to the capital market in the diversification of risk achieved in purchasing such investments.

The banking and capital markets are used because of capacity issues and because the risks involved are ones with which the banking and capital markets are comfortable.

A key point to note about securitisation is that it is making insurance products look much more like banking products. The reverse, often called *insuritisation*, is making banking products look more like traditional insurance.

We now look at three specific types of securitisation:

- insurance-linked securities
- credit securitisation
- motor securitisation.

Insurance-linked securities (ILS)

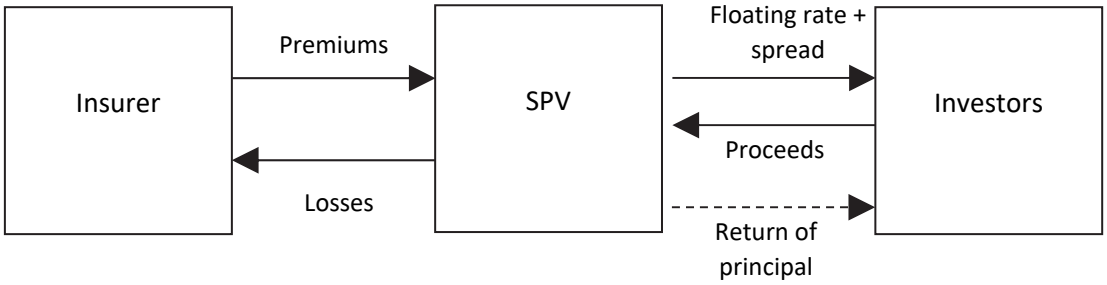
Insurance-linked securities (ILS) are an innovative way of increasing (re)insurance capacity. The valuation and performance of these financial instruments are driven by the occurrence (or lack of occurrence) of insurance loss events. ILS offer acquirers (such as institutional investors and pension funds) an opportunity to invest in instruments, the returns from which are largely uncorrelated with other financial assets and macroeconomic movements and allow them to exclude surrounding risks (such as the market risk in share prices) of investing in reinsurance companies. For purchasers, who are typically insurers or reinsurers, ILS provide an additional source of protection and insurance risk mitigation instruments.

From the launch of the first securitisation in the 1990s, the ILS market has grown and cemented its place as a complementary alternative to reinsurance, notably in the property catastrophe reinsurance market. It has developed into what is now a reasonably liquid catastrophe (cat) bond market. These catastrophe bonds allow (re)insurers to transfer high severity low probability catastrophic risks to the capital market and spread them among many investors: if the specified catastrophic risk is triggered, the bondholders typically forfeit the interest and principal on the bond to the (re)insurer. If there is no catastrophic event, or trigger event before the maturity date of the contract, investors receive back their principal investment at maturity on top of the interest payments they have received.

You may be confused by the fact that the (re)insurers are referred to as 'purchasers' in the first paragraph of Core Reading above. This is because an ILS involves a corporate entity called a Special Purpose Vehicle (SPV) that sits between the (re)insurer and investors.

An SPV is a subsidiary established by a company to 'fence off' financial risk. The SPV is bankruptcy-remote from the parent company – in other words the bankruptcy of the parent doesn't affect the SPV and vice versa.

For example, a typical cat bond structure would be:



As shown in the diagram, the investors purchase the bonds but the (re)insurer pays premiums to the SPV to purchase the protection afforded by the contract. It is more common to refer to the (re)insurer as the 'sponsor' of the ILS rather than the 'purchaser', to avoid any confusion.

Cat bonds developed primarily in response to the hard market (*ie* high premiums) of traditional catastrophe reinsurance in the 1990s.

There can be many variations, and many types of trigger event.

The basic advantages of ILS are that they:

- increase insurance capacity by transferring risk to the capital markets
- mitigate counterparty risk as funds are held in a secure independent vehicle.

Credit securitisation

Although not usually involving reinsurance, insurance companies have been active in the credit securitisation markets.

Their main roles have been:

- **enhancing the creditworthiness of debt instruments**
- **providing capital relief to banks by insuring loan portfolios**
- **providing credit protection to companies.**

Enhancing the creditworthiness of debt instruments / providing capital relief to banks

Consider a bank securitising some of its loan portfolios. The interest and capital repayments under the loans will be securitised and used to pay the interest and capital repayments under the debt instruments (*ie* bonds).

Investors will require a return on the bonds that is adequate to compensate them for the risk of default. The bank may want to keep the return on the bond as low as possible, therefore it must try to ensure that the bond is relatively secure. In order to do this, it must either securitise its best quality loans (*ie* the loans with the lowest risk of default), or it must securitise a large number of loans relative to the number of bonds issued (in which case, even if the loans default, there will still be an adequate number of bonds left with which to make payments on the bonds).

The first of these options may not be available if the bank does not have (or has already securitised) a portfolio of 'safe' loans. The second option may be undesirable, because effectively, the bank is using up a lot of its business in the securitisation, which will reduce its profits.

A third option is to use insurance to reduce the credit risk of the bonds. The bank insures the bonds so that their return is guaranteed (as long as the insurer does not default). If the payments under the loan portfolio are not sufficient to meet the interest and capital payments under the bond, then the insurance will kick in and make the payments to the investors.

Having insurance as an underlying guarantee will enhance the creditworthiness of the debt. This will help to ensure that the bank does not need to pay a very high rate of return on the bonds, or, equivalently, does not need to sell them cheap. It should therefore be able to sell the bonds at a relatively high price, thus maximising the capital relief provided by the securitisation. This needs to be weighed up against the cost of insuring the bad debt.

This type of arrangement falls into the category of capital management, as described above.

Providing credit protection to companies

There are numerous types of credit securitisation arrangements, although the basic contract is a *credit default swap*, which is essentially an agreement to compensate the 'insured' (*ie* the buyer of the swap) if a specified credit event occurs (*eg* bankruptcy or loan default of another company).

Note that for each of these arrangements, the insurer is not usually one of the two parties involved in the securitisation itself. Instead, it is a third party providing insurance against the risk of default by another party.

These alternative risk transfer (ART) solutions use derivative products available in the capital markets, in addition to variations on traditional trade credit insurance.

Motor securitisation

Another capital market product is motor securitisation (where certain aspects of a motor insurer's portfolio risks are passed to the investment market).

The insurer issues a bond where the coupon payments depend on the claims experience of the insurer's motor portfolio. If the insurer experiences poor claims experience, it may forego some or all of its repayments. Thus, the insurance risk is transferred to the capital markets instead of to the reinsurance market.

As with other debt issues, these bonds are tradable financial instruments.

Structured finance

The term 'structured finance' is sometimes used interchangeably with 'securitisation'. However, it is also used to refer to a broader class of financial arrangements designed to transfer risk using complex legal and corporate entities.

Reinsurers became involved in structured finance through their finite reinsurance business and the increasing need of financial guarantee insurers and investment banks for additional capacity.

The typical financing solution provided by the reinsurer is a credit enhancement in which the reinsurer provides a financial guarantee or credit insurance wrap to the institution borrowing from the capital market.

Credit enhancements involve insurance companies insuring loan portfolios or providing credit protection to companies to improve the creditworthiness of debt instruments. These solutions use derivative products available in the capital markets, in addition to variations on traditional credit insurance.

Credit insurance wraps are insured or guaranteed by a third party. The third party may provide a promise to reimburse losses up to a specified amount. The third-party guarantees are typically provided by AAA-rated financial guarantors.

Credit enhancement or financial guarantees lower the cost of borrowing.

3 Climate change and environmental factors

The natural environment leads to many insurance claims, including some of the most spectacular ones. Recent concerns about climate change have raised the prominence of this issue, but normal trends in weather and the incidence of spectacular events mean that weather-related losses are inherently unpredictable from year to year. The human-made environment can also be a cause of claims in ways that are not always obvious in advance.

This section covers:

- the impact of the weather, including seasonal effects (which will depend on the characteristics of the property being insured), and the possible implications of global warming
- catastrophes, including weather-related events (particularly hurricanes), and factors affecting the financial impact of these; earthquakes and examples of human-made catastrophes are also discussed
- latent claims, giving lots of examples, and how insurers have tried to deal with latent claims.

3.1 Weather

Seasonality

The most obvious way in which weather varies, in most countries, is seasonality. In temperate climes there is the spring / summer / autumn / winter pattern; in tropical climes there may be a dry season / wet season pattern or a monsoon season. The precise pattern and the dangers associated with each phase will vary from country to country even within geographic zones, with differences in weather patterns and building codes, among other things.

Building codes are the standards to which houses, offices, bridges, *etc* must be constructed. For example, in territories prone to earthquakes, such as California and Japan, there are regulations to ensure that all new buildings are built to standards to withstand earthquakes of a specified intensity.

In areas where the standard of building construction is high, insurers should bear lower losses.

In general, winter weather is harsher and for some classes is more likely to give rise to claims: storm damage is more likely and driving conditions are likely to be more treacherous, including the fact that there are fewer hours of daylight. This is rarely of concern to insurers, since most policies are issued for a year and will be in force through all four seasons. However, in extreme cases it may influence patterns used to earn premiums, *eg* catastrophe reinsurance in the US.

The unearned premium reserve (UPR) is usually calculated by taking a portion of premiums in respect of the unexpired exposure period. Often, this is done on a straight averaging basis, *eg* for an annual policy with six months to go it might be reasonable to take half of the premium. However, if the risk is not uniformly spread over the year of cover, *eg* where the claim costs vary according to the time of the year, the proportion of premium taken should reflect the expected risk in the unexpired period.

In calculating UPR, an allowance might be made for initial expenses. The calculation of the UPR is discussed in more detail later in the course.

Subsidence and land heave

Although the weather in summer is generally more benign than in winter, the problems of subsidence of buildings and heave are generally more likely to arise in the summer, particularly when it's very dry and hot. The shrinkage of land on which houses are built as the ground becomes desiccated (dried up) **leads to damage to the houses, which is exacerbated when the drought breaks and the ground expands again. This can lead to a large number of claims for structural damage to property, especially domestic property, many of which can be large. Also, when the damage is not caused over a short period of time, as it might be with a storm, catastrophe XL reinsurance may not respond to these losses.**

Heave is essentially the opposite of subsidence. Whereas subsidence involves a downward movement of land due to a reduction in hydration, heave involves an upward movement due to increased soil hydration. Heave could occur after trees are felled in an area because they will no longer absorb moisture from the soil.

Question

Suggest why the catastrophe XL (excess of loss) reinsurance may not have covered many of the subsidence claims.

Solution

Catastrophe excess of loss reinsurance covers catastrophic events. An event is defined as a number of claims occurring within a short period of time (defined in the hours clause in the reinsurance treaty). Many subsidence claims will have been deemed to occur outside of this period, and so would not be counted in the total claim amount used to determine the reinsurance recovery.

Location of property

Different areas are obviously subject to different climates, but the vulnerability of particular properties to weather events will vary in ways that are not always obvious and make underwriting difficult for a mass product. Places close to each other will suffer almost the same weather, but some locations are more sheltered than others and some will be more prone to being flooded. Obviously, properties built on flood plains are prone to flooding, as are those on low lying lands near the coast, but other vulnerable places may not be so obvious: where water is channelled as it runs downhill it may make some hillside properties vulnerable to flooding.

So two properties might be in the same small town but have a very different weather-related risk because:

- one is in a sheltered, dry spot under a hill
- the other is in an exposed area, next to a river.

Some insurers are dealing with this issue by, for example:

- requesting more precise details about the location of the property and previous claim history
- rating according to a more precise measure of location – *eg* using full postal code, rather than just the first few characters.

Climate change

Climate change refers to long-term changes in average weather patterns. Scientific consensus has linked climate change to the rise in average global temperatures due to human activity associated with greenhouse gas emissions.

Climate change is anticipated to significantly impact the availability, affordability and demand for (re)insurance in the coming years. Climate change is expected to result in increased intensity and frequency of extreme weather events such as heatwaves, heavy precipitation, droughts, flooding, and tropical cyclones.

The term 'tropical cyclone' refers to a storm system comprising a large area of low pressure at the centre together with thunderstorms that result in heavy rain and fast winds. Tropical cyclones can be subdivided based on location (and strength) into typhoons (northwest Pacific), hurricanes (northeast Pacific and northern Atlantic), tropical storms or tropical depressions.

The increased hazards could lead to increased claim costs and affect the insurability of some types of risks, regions and lines of business. For example, as the sea level rises and the risk of flooding increases, some coastal areas may become uninsurable. Similarly, existing infrastructure built without sufficient consideration for resilience to climate risks may also become more expensive to insure.

If properties in some areas become substantially more vulnerable to loss, to the extent that their owners struggle to find insurance cover, this may lead to political issues.

Many people feel that governments have a moral obligation to protect householders from flooding. This is demonstrated through state-funded construction of flood defences, such as the Thames barrier in London. In some territories, such as France and the United States, flood protection is provided through government insurance or pooling arrangements. In others, such as the UK, if flood defences fail or are inadequate, the householder may be left paying, and so will need to buy private insurance.

A concern in the UK has been that those on low incomes may be unable to afford home insurance, *eg* if they live in low lying properties or coastal areas.

Therefore, the UK government and the insurance industry have set up a fund called Flood Re, to provide affordable flood insurance to high-risk policyholders by taking the flood risk element of home insurance from an insurer in return for a premium based on the property's Council tax band.

In other words, the policyholder buys home insurance from an insurer as normal, but the flood risk element of the policy is covered by Flood Re.

Flood Re is financed by a levy on all insurers relative to their share of the home insurance market.

Question

Climate change is seen as a long-term effect. Suggest some short-term measures that general insurers could take each year in response to the resulting adverse claims experience.

Solution

A general insurer could respond to adverse claims experience by:

- increasing premiums, either overall or for certain risks
- changing its benefits, *eg* exclude specific perils
- strengthening underwriting or claims control measures
- no longer selling certain products
- revising its target market, *eg* stopping marketing activities in certain locations
- strengthening its reinsurance programme, where this is feasible.

Beyond the physical risks, insurers also face transition and additional liability risks from efforts directed towards mitigating climate change. These risks may become more pronounced as the world moves towards a low carbon economy aimed at minimising greenhouse gas emissions. As a result, insurers may experience a change in risk profiles and emergence of new risk types. For example:

- **changes in commercial risks due to adoption of more sustainable manufacturing processes**
- **changes in motor liability risks due to replacement of fossil fuels with renewable energy sources**
- **increased product liability risks from adoption of technological high energy storage batteries which have a high risk of overheating and explosion**
- **pressure to withdraw insurance support from companies in the fossil fuel sector, *eg* coal producers and oil companies**
- **emergence of liability risks for insurers manifesting as litigation against existing policyholders for failure to mitigate, adapt and disclose climate risks they faced.**

Climate-related risks to the insurance industry can be separated into three categories:

- physical risks
- transition risks
- liability risks.

A physical risk is one due to extreme events caused by climate change. For example, the risk of an increased frequency of hurricanes leading to increased insurance losses.

A transition risk is one associated with society's transition towards a low-carbon economy. For example, the risk that government policies implemented to reduce global warming might reduce the value of assets held by an insurer, *eg* holdings in fossil fuel companies.

Liability risks are ones associated with compensation claims for losses due to physical or transition risks. For example, the risk of increased losses in Directors' and Officers' insurance due to claims against companies (*eg* electricity providers) for failing to consider climate change in their strategy.

Reinsurance availability is also likely to change. For example, reinsurers may increase their rates and place caps on exposures from particular perils or regions reducing the availability of cover. If an insurer relies on reinsurance to provide cover for large risks or significant accumulation risks, then the insurer's underwriting capacity may be diminished.

3.2 Catastrophes

Catastrophic losses can take the form of one immense loss, such as an oil-rig explosion. Alternatively, there may be many smaller insured losses, all stemming from a common, identifiable event such as a hurricane.

One way to reduce the impact of catastrophic losses is to write business in a wide range of geographical locations and across many classes. Catastrophe reinsurance will also help.

Catastrophes may be either natural or human-made in origin.

Examples

Natural catastrophic losses include:

Ice, snow, frost: Widespread property damage may arise from water damage caused by burst pipes. There will also be many more claims for accidents from the motor account.

Storms: Severe storms (*eg* wind, hail or rain) can cause extensive damage to property. There may be a large number of claims from agricultural or motor policies in a region hit by a hailstorm or household property damage from wind storms or flooding (*eg* parts of the UK in the winter of 2015).

Earthquake: Potentially massive damage to property classes (*eg* Los Angeles earthquake in 1994).

Fire: Large fires can cause extensive property damage (*eg* Australian bushfires in 2019-2020, largely ignited by lightning). These are most often seen in hot, dry territories. Catastrophic fires can also be human-made, *eg* due to accidental or deliberate ignition.

Human-made catastrophic losses include:

Air crash: *eg* Shoreham Air Disaster (UK) in 2015. This could affect the aviation or public liability classes. If the problem is a design fault, claims could fall on the manufacturer's product liability cover.

Explosion: *eg* oil depot at Buncefield (UK) in 2005, the Piper Alpha oil rig in 1988. Losses could hit property, employers' liability, public liability and/or consequential loss policies.

Terrorism: *eg* terrorist attacks on the World Trade Centre in New York on 11 September 2001.

Hurricanes, storms

Although the US is cited for having the most expensive weather incidents, more recently, events in New Zealand, Australia and South East Asia have reminded us that 'weather' is a worldwide phenomenon.

The pre-eminence of the US in this regard is partly because of the concentration of high insured risks and partly because of the vulnerability of the coast of the Gulf of Mexico and the Atlantic states' littoral area to hurricanes.

Littoral means pertaining to the coast.

As mentioned before, the high total cost of insurance claims from weather-related events in the US compared to other countries can be partly attributed to:

- the large number of properties in certain areas, particularly in cities along the eastern coast
- the high proportion of properties that are insured
- the high average value of these properties.

In addition, the US states of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina and Texas are particularly prone to hurricanes.

It is normal seasonal behaviour for tropical storms to form over the Atlantic Ocean and track in a westerly direction, some forming hurricanes in the Caribbean, the Gulf of Mexico and on the US's south-eastern coast. They tend to cause damage – sometimes very serious damage – in Caribbean states, but the concentration of insured values there is low. Whether or not they are serious events in global insurance terms depends partly on their strength, but more on whether they affect the US and where in the US they land.

The most expensive weather incident ever recorded (at the time of writing) **is Hurricane Katrina, which hit Louisiana in the autumn of 2005. Although it was a very strong storm it was not uniquely strong, and not in fact the strongest storm to hit the US in 2005 (that was Hurricane Wilma slightly later that year). However, Hurricane Katrina passed almost precisely over the city of New Orleans, which proved to be particularly vulnerable. This type of effect adds to the uncertainty of underwriting property insurance in loss-prone areas.**

Part of the reason for there being such extensive damage was that Hurricane Katrina weakened a main levee (breakwater) protecting New Orleans. Six days later the levee broke, resulting in flooding to approximately 80% of New Orleans and subsequent loss of lives, damage to property and much looting in and around the city.

Rising cost of major losses

It has been observed that the cost of major losses has risen substantially. This is largely due to economic development. Some of the areas in the US most vulnerable to storm losses have been at the forefront of development. Florida is a major holiday destination, which has led to a great deal of development near the coast. It is also a low-lying state which makes it vulnerable to hurricanes.

Low-lying states are vulnerable to coastal flooding associated with hurricanes.

Another cause of increases in the cost of disasters is a general trend towards taking out insurance. Insurance cover is not universal even in developed economies; in less developed economies it can be the exception rather than the rule. However, in almost all countries property is more likely to be covered by insurance than it was some years ago. This means that the proportion of economic loss covered by insurance in any catastrophe is higher than it used to be. An obvious consequence of the difference in the proportions of properties insured in various places is that a catastrophic event in a less developed country can cause only modest insurance losses whereas a similar event in a developed country can give rise to very heavy losses.

Earthquakes

Earthquakes are occasional events that may lead to heavy insured losses. Geological structures determine an area's vulnerability to earthquakes in general, and the most vulnerable areas are well known, although small events are not unknown elsewhere. Most areas of greatest vulnerability are areas of low insurance intensity, but there are important exceptions; notably Japan, including Tokyo, and the San Francisco and New Madrid areas of the US.

On the other hand, the Asian tsunami of December 2004 – caused by an offshore earthquake that was one of the largest ever recorded – caused about 230,000 deaths and widespread devastation, but relatively little insured loss. In March 2011, an earthquake hit the northeast coast of Japan, causing a 10-metre tsunami. Over 20,000 lives were deemed dead or missing and over 100,000 buildings were totally destroyed.

Other natural perils

Other natural catastrophe perils include flood, typhoon, hail and volcanic eruption.

In some countries there are nationally-administered insurance schemes that may effectively provide some or all of the cover for certain catastrophe perils.

Human-made catastrophes

Human-made catastrophes consist mainly of terrorist incidents, industrial accidents and conflagrations.

A conflagration is a large destructive fire, which can be difficult to control.

Terrorism may or may not be covered by insurance, depending on local practice and law. Terrorist incidents give rise mainly to property damage claims but may give rise to liability claims if security measures are found to have been inadequate.

In some territories, such as in the UK, claims arising from terrorist attacks are covered by the government-backed arrangements. In these circumstances, insurance contracts tend to specifically exclude claims resulting from terrorism. (In some cases, such as in the UK prior to the 2001 WTC attacks, insurers would cover claims up to a specified monetary limit, and the government-backed arrangement would pay claims in excess of this.)

3.3 Latent claims

Latent claims derive from perils that were unforeseen when the policy concerned was signed. Students should note, however, that the term is also applied to any insurance claims that become known some years after the cause of loss. Most of these arise from diseases caused by products or industrial processes, but faulty construction of buildings is another possibility. Claims arising from the sexual molestation of people, particularly children, is another example.

Most latent claims will therefore arise under product liability and employers' liability insurance. This is not necessarily the case however. Faulty building construction could probably be covered under architect's professional indemnity insurance or a contractor's construction all risks (CAR) cover. Child sex abuse claims may arise under public liability insurance.

Examples of types of latent claim

The most notorious classes of claims of this nature are those arising from asbestos.

Numerous employers' liability (and some product liability) claims are arising in respect of workers that handled asbestos materials and products. Although some of those affected were exposed to asbestos from as early as the 1940s, the resultant lung conditions (*eg* asbestosis and mesothelioma) did not begin to materialise until about 1980.

Some other latent claim classes are listed below. These include claim causes that appear to have run their course, others that are still in the process of manifesting themselves and others that have caused concern but may or may not develop into significant sources of loss:

- **Agent orange.**

  This was a chemical defoliant that was sprayed over Vietnam by the US army in the 1960s. Many of the soldiers based there have sued against the manufacturers of the chemical for consequent health problems to themselves and their families (*ie* for birth defects). Most of these claims were made in the 1980s. More recently (2006), Vietnamese victims have tried unsuccessfully to make claims.

- **Radiation from mobile phones.**

  It has been suggested that this might be linked to an increased risk of some cancers (particularly in children), headaches or sleeping problems. To date, no definite link has been proven, but research continues.

- **Benzene.**

  Exposure to benzene can cause serious health problems, including some cancers. The chemical has been found in some carbonated soft drinks, which were, of course, immediately withdrawn from sale.

- **Diethylstilbestrol** (DES).

  This is a drug that was given to millions of women in the US in the middle of the 20th century to reduce the likelihood of premature births. However, it has been linked to genital abnormalities in daughters, and even potentially in granddaughters.

- **Electromagnetic fields.**

  These are linked to the increased risk of leukaemia and other cancers.

- **Pollution.**

  Exposure to pollution may last several months or years. The impact on health of being exposed to polluted conditions may not be apparent for many years.

- **Guns.**

  In the US, there have been attempted claims for compensation against gun manufacturers:

  – by victims of accidental shootings
  – by city councils, for the increase in gun crime
  – by gun users, where accidental injury has been caused.

  To date, most of these claims have been unsuccessful.

- **Noise-induced deafness.**

  Most commonly, this is due to working with, or being exposed to, noisy machinery (*eg* with pneumatic drills or beside aircraft).

- **Blood products infected with HIV or hepatitis.**

  During the late 1970s and early 1980s, large numbers of haemophiliacs became infected with HIV or hepatitis after receiving tainted blood-clotting substances.

- **Sick building syndrome.**

  The building people work in can be blamed for a range of illnesses, such as irritation to the nose, throat and eyes, fatigue or headaches. This could be attributed to micro-organisms within the air conditioning or the humidity of the building, but the specific causes of these conditions are generally difficult to prove.

- **Latex gloves.**

  Some people are severely allergic to latex rubber. Examples of compensation claims are:

  – under employers' liability coverages, from hospitals sued by workers that have been made to wear latex gloves
  – under product liability coverages, from glove manufacturers sued by customers wearing, or patients treated by medical staff wearing, latex gloves.

- **Lead paint.**

  Lead is added to some paint to improve its performance, *eg* in drying quickly. It can be damaging to health, in particular hindering the development of young children. Now that the dangers are known, it should only be used in certain circumstances, *eg* for painting road surfaces. There are potential product liability claims against paint manufacturers, and some public liability claims, *eg* against landlords.

- **Bovine spongiform encephalopathy (BSE)**.

  BSE is commonly known as 'mad cow disease' as it affects the brains of cattle. It was first found in the mid-1980s, mainly in parts of Europe. However, 10 years later a brain disease (known as vCJD) was found in humans, causing several deaths, and there is evidence to suggest that some victims may have caught the disease by eating meat from BSE-infected cattle.

- **Toxic mould.**

  There have been houses and other buildings in the US, particularly in Texas, where types of mould that emit toxins have been claimed to cause health problems and damage to property. Among the parties being litigated against are builders, architects and owners of buildings (such as schools).

- **Dalkon shield.**

  This is a contraceptive intrauterine device that was found to cause severe injury to a disproportionately large number of its users.

- **Repetitive strain injury** (RSI).

  RSI is a generic term used to describe a range of painful conditions of the muscles, tendons and other soft tissues. It can affect the upper limbs, neck, spine, or other parts of the musculoskeletal system. They are generally caused by performing work-related, usually repetitive, tasks, and so they can lead to employers' liability claims. Vibration white finger (from using vibrating machinery, such as pneumatic drills) is a traditional example, although conditions related to computer use (*eg* poor posture) are more prevalent nowadays.

- **Silica dust.**

  A fine silica dust can be produced when certain types of rock are cut, drilled, *etc*, which can cause lung diseases if inhaled. Foundry workers and people working with the products produced (*eg* potters and sandblasters) are most at risk unless proper precautions are taken. It can take, say, 10 to 15 years following exposure before symptoms develop.

- **Tobacco.**

  Smokers and their families have taken tobacco companies to court for illnesses, injury or death caused by long-term smoking. Most cases have been in the US, where some medical insurance providers have also claimed compensation from the tobacco companies.

- **Year 2000 computer systems.**

  Towards the end of the 1990s, there was a huge fear that many computer systems and products that relied on microprocessors would fail in the year 2000. This concern arose because early computer programs often use a two digit code for the year component of dates and the ambiguity of the date '00' may lead to incorrect calculations. Products that may have failed include computers, machinery, lifts and safety equipment. Failure on safety equipment may also have led to employers' liability claims. Companies and organisations all over the world checked and upgraded their computer systems in preparation for the 'millennium bug', and no significant computer failures occurred when the time came.

- **Nanotechnology.**

  Nanotechnology is the ability to work with materials on an extremely small scale, *eg* 100 billionths of a metre or less. This is still a developing field, but nanomaterials are already being incorporated into many products worldwide, including cosmetics, paints, medicines and food products. However, there is very little knowledge about how nanomaterials may affect the long-term health of workers and consumers.

  Any tort litigation arising from the alleged harmful effects of nanomaterials could impact manufacturers, distributors, secondary users (*ie* producers who incorporated nanomaterials into other products) and retailers. Insurers writing employers' liability, general liability and product liability could therefore be affected.

- **Opioids.**

  Opioids are a class of addictive painkillers regularly prescribed by doctors. They have been the subject of much controversy in the US where doctors have been accused of over-prescribing the drugs and pharmaceutical companies have been known to market their products aggressively to doctors and consumers alike. The resulting 'addiction epidemic' is taking thousands of lives annually and causing millions of dollars of economic losses. This has led to litigation against pharmaceutical manufacturers, distributors, pharmacies and general practitioners. The resulting insurance claims have impacted product liability, 'druggist liability' insurance (for pharmacies), errors and omissions policies, and general liability policies.

- **Sexual harassment / #MeToo movement.**

  Sexual harassment cases have received a great deal of publicity in recent years, leading to a rise in related insurance claims. Denunciations are often made public early in proceedings, which can quickly lead to multiple claims. Claims could arise on several liability classes, *eg* D&O, public liability, general liability, employers' liability, *etc*. However, some reports suggest that most insurance claims are arising from employers' liability products.

- **Sexual molestation.**

  These cases are similar to the sexual harassment claims listed above, but probably relate more to child abuse or abuse of vulnerable people. In the context of latent claims, historical abuse is probably most relevant. (Note that the insurance would not benefit the perpetrator in these instances. Rather, the coverage is designed to protect institutions such as employers, schools, care homes, *etc* who are subject to defamation or litigation.)

Problems with latent claims

One problem with latent claims is that it is impossible to know where the potential claim is lurking. Also, if the claim does materialise, the future claim cost is completely unknown.

For example:

- Will there be future employers' liability claims for damage to people's eyes from using computers too much?
- If so, how much will the claim amounts be and how many people will be able to claim?

There is also the problem of identifying when exactly the claim event occurred, especially if exposure (*eg* to the harmful substance or working conditions) was over many years.

Most latent claims arise in liability insurance. The normal form of these policies was the occurrence basis in which a claim would always be paid from the year of account in which the damage was caused. This leads to problems of definition: if a person who worked with asbestos for a number of years, possibly with several different employers, contracts mesothelioma some decades later, how can it be traced to a particular year of insurance? The answer is that a legally imposed or industry agreed method of allocation must be found.

It may be difficult to identify the claim event date. However, the claim notification date should be readily identifiable and objective.

Partly as a response to this the claims made policy was developed in the 1980s. This is now the standard form of policy for professional indemnity insurance and some other liability classes. It is intended to cover all claims that were first notified in the year of insurance. However, the cover granted may be unsatisfactory from the claimant's point of view, and even more so from the point of view of a claimant who depends on the tortfeasor's insurance to obtain redress. When a claim arises the tortfeasor may no longer exist, and if latent claims are emerging they may have trouble obtaining continued cover.

So, for example, say an employer took out liability insurance on a claims-made basis. If it is known that the employer exposed its workers to hazardous conditions, it will be difficult for it to get cover that is either affordable or comprehensive enough to cover future claims. This is because insurers will fear a large number of claims being notified in the coming year.

For reasons such as this occurrence cover may be required in areas where insurance is compulsory, such as UK employers' liability.

Liability insurance is intended to protect the insured against the cost of having to pay compensation, rather than to protect the third-party victim. However, such insurance is compulsory to ensure that victims can be compensated. It is therefore common for victims to be able to claim directly from insurers where the tortfeasor no longer exists, having ceased to trade for example.

Latent claims are covered in more detail in Subject SA3.

Question

Suggest two examples of factors that the insurer would be unaware of, but that could change the development pattern.

Solution

Examples include:

- a change in the propensity of individuals to report claims quickly – this may be a gradual change, *eg* due to longer working weeks (and so less free time to report claims)
- changes in processes of brokers regarding claims processing / reporting, for business sold through brokers.

Demand surge

Following a major catastrophe, there will be increased demand for goods and services in the affected areas.

For example, the demand for builders may increase following a flood. This increase in demand could force up the price for such goods and services to an unpredictable extent.

Higher prices could mean higher claim amounts.

Climate change

Climate change is expected to be an increasing source of risk and uncertainty for insurers. Insurers will need to assess the extent to which they can rely on historical experience considering the significant impact climate change is likely to have on future claims trends.

Historical occurrence patterns for weather-related claims may no longer be appropriate as climate change is expected to result in increased frequency and severity of extreme weather events for varying degrees in different areas. Several studies have linked recent natural catastrophes to climate change. For example, the precipitation from Hurricane Harvey in 2017 is estimated to have been made 15% more intense due to climate change, and one of the most intense Atlantic hurricane seasons was recorded that year.

Additionally, climate effects are expected to vary regionally with either increased or decreased correlations between regional perils. For example, areas like Bangladesh are expected to experience more rain whilst the South-Western US is expected to experience more droughts.

Climate risk may introduce dependencies or 'ripple effects' across different risk types, regions or business classes. For example:

- **A flood event can also lead to business continuity and supply chain risks, further increasing uncertainty.**

  Potential increased frequency and severity of flood events could therefore be a common driver of worsening claims experience in a number of classes, where we might not previously have expected to see much correlation, *eg* trade credit insurance and household insurance.

- **An increase in sea level due to melting ice-caps may lead to more losses in a region, causing mass migration and changes in economic activity levels with consequences for the availability and performance of investment assets.**

  Hence, amongst other things, climate change could lead to added dependency between insurance risk and market risk.

- **Existing sectors of the economy that are a source of insurance business may be severely impacted by technological or regulatory disruption, leading to strategic challenges and a period of heightened uncertainty whilst new markets are developed.**

Bodily injury claims

Some governments have introduced legislation concerning the payment of bodily injury claims. The idea is that to indemnify the policyholder, the claim payment should be in the form of income replacement, instead of a lump sum. This effectively increases administration, resulting in higher claims servicing and reporting costs for a longer period and hence higher claims handling reserves.

Insurers could get around elements of this problem through the purchase of an annuity. However, annuity prices can be volatile, and will also include a profit loading for the annuity provider. Therefore, the insurer may prefer not to go down this route, and it does not remove either the additional administration or reporting issues.

This type of legislation can also apply retrospectively.

This means that legislation may be applied to claims that have already been reported.

Differences in third party behaviour (*eg* lawyers actively seeking out asbestos claimants)

The behaviour of third parties may also impact claim characteristics for certain classes.

For example, lawyers may actively seek out people affected by asbestos-related illnesses, or PPI business. This would increase the claim frequency and may also have an effect on severity.

Recall that PPI insurance is another name for creditor insurance. It has become the most complained about financial product ever in the UK, as it was mis-sold to consumers on an industrial scale.

Question

Suggest how claim severity might be affected by lawyers seeking out people affected by asbestos-related illnesses.

Solution

If lawyers seek out people who have been affected by asbestos-related diseases, there may be a general increase in awareness and/or an increase in publicity over asbestos cases. As a result, there may be an increase in awards made by courts over asbestos-related claims.

On the other hand, those with less severe conditions may be more likely to make claims, which could lead to a reduction in average claim sizes.

Government legislation

Relevant legislative actions can be divided into three main types:

- Tax changes, *eg* an increase in value-added tax (VAT). Many claims are settled on a replacement basis (*ie* the insurer replaces the damaged item), so if the VAT on the insured item increases, the cost of replacing that item will increase and the claim cost will increase.
- Changes in the law that increase the amount of cover being provided, such as removal of a legal limit on compensation levels.
- Changes in the law that restrict or forbid the use of certain factors in underwriting.

In the first two cases, an insurer is unlikely to have foreseen such changes. Since premiums cannot be changed retrospectively, the changes will adversely affect profits until some time after the premiums or cover can be adjusted. The third type of change will be known about in advance, but may expose the insurer to anti-selection for which the cost cannot be accurately assessed. This may result in the need for higher reserves to allow for this risk.

In the past, legislation has tended to increase the burden on insurers.

This will affect future claims and claim development patterns.

For example, legislation may have changed to require the insurer to pay for the cost of an ambulance to attend a road traffic accident.

This legislation has been in force for many years in the UK, although many hospitals don't claim these costs from the insurer.

Such legislation can be retrospective, thereby including historical claims as well as incurred but not reported (IBNR) claims.

The effect of economic conditions on claims

Many types of incident giving rise to claims are influenced by economic conditions, whose changes are difficult to predict as regards both timing and extent. There is therefore a continuing uncertainty as to the number and cost of the claims that will occur when conditions change.

Mortgage indemnity is one class that is heavily affected by economic conditions.

A number of economic variables could have a direct impact on claims. For example:

- inflation – this will directly affect claim amounts

Question

Outline three types of inflation that can affect claim amounts.

Solution

1. price inflation, which will affect the replacement costs of goods
2. earnings inflation, which will affect repair costs and loss of earnings claims
3. court inflation, which will affect claims that are settled in the courts

- unemployment – this could lead to certain sections of society being unable to afford insurance, and so produce a different mix of business
- economic growth – this could lead to more sections of society being able to afford insurance (and higher levels of cover in some cases), and so produce a different mix of business
- change in the value of the exchange rate – for business transacted in a currency other than that of the country in which the insurer is based, there is a risk that the insurer's results will be adversely affected by changes in the exchange rate between the two currencies; there will also be uncertainties stemming from currency mismatching between assets and liabilities, and because it may be impossible to predict the currency in which a claim will have to be settled.

Question

Suggest three examples of general insurance classes in which there is likely to be a high level of uncertainty relating to the currency of the claim payments.

Solution

Marine, aviation and travel.

These are probably the most obvious but you could also mention product liability, commercial motor, etc.

In addition, the economic conditions can have a wider impact on the environment; for example, crime rates may increase during recessions.

The rates of crimes such as theft and arson have shown considerable variation from year to year and from country to country. General insurance companies might actively engage in trying to encourage policyholders to take steps to reduce crime, in a hope of reducing claim costs.

1.2 Internal sources of process uncertainty

Planned or unplanned changes in mix

Different risks will exhibit different claims characteristics, *eg* claim frequency, severity, volatility, timing of payments, *etc*. The degree of uncertainty inherent in the business will therefore depend on the mix of risks that have been written.

In addition, any changes in the mix of business will increase this uncertainty.

Question

(i) Suggest possible strategies that might lead to a change in business mix.

(ii) Suggest other reasons why the business mix might change.

Solution

(i) ***Strategies leading to a change in business mix***

- strategic change in target market
- change in distribution channels used
- change in marketing method
- change in pricing structure
- change in underwriting processes
- change in claims handling procedures

(ii) ***Other reasons why the business mix might change***

- increase in anti-selection by policyholders
- change in the attitude to claiming
- change in fiscal regime, *eg* tax relief on certain groups of policyholders buying insurance
- change in regulatory regime, *eg* certain types of insurance becoming compulsory
- change in company reputation, *eg* a company becoming seen as a budget provider

Booked reserves different to best estimate

Although the reserving actuary will typically **calculate the best estimate reserves, and possibly reserves for financial reporting, the final decision in respect of reported reserves (and maybe solvency reserves) will rest with the company directors. The directors may decide to be conservative by booking a result that is more pessimistic than the best estimate. If there is pressure on results, then the reserving actuary may be put under pressure to produce a lower best estimate figure. If this is the case, then the actuary can take a number of steps including discussion with other members of the profession. Management decisions can have an unpredictable effect on published reserve levels and management may choose to book reserves below the estimates of the actuary.**

Reserves booked will usually be greater than best estimate due to:

- **desire for conservatism**
- **smoothing of results**
- **requirements of regulatory bodies**
- **influence of auditors or external reserving actuaries.**

New markets

Entering a new market or territory will incur expenses for the insurer, including set-up fees, accommodation costs, fees to the regulator and legal costs. Some of these will be known in advance with relative certainty. Others will be unpredictable.

New distribution channels

Claims frequency, severity and development may be expected to vary by distribution channel.

If the use of a new distribution channel tends to attract policyholders with different characteristics from those of the existing clientele, the resulting claims experience may differ from that of the past in an unpredictable way.

For example, direct sales may be expected to develop more quickly than broker sales if claims from broker sales are reported through the broker.

The internet is now the dominant sales channel for personal lines and smaller retail products. The lack of a face-to-face meeting or a telephone call when buying a policy certainly increases the possibility of fraud, which could affect frequency and claims development patterns.

The number of distribution channels is likely to increase in the future, as insurers pursue ever more innovative ways of attracting new business and reducing costs.

New channels may also create a knock-on effect on existing channels. For example, if the internet channel increases, the broker channel may shrink, resulting in brokers offering incentives to attract business. This will have an effect on premiums and claims patterns.

New claims handling procedures (*eg* online claims reporting)

Some insurers offer an online claim reporting service. This may increase policyholders' propensity to claim, thereby increasing claim frequency. It may also have other effects such as increasing the speed of notification of losses.

It may also cause an increase in fraudulent behaviour; for example, policyholders reporting non-existent claims, or exaggerating existing claims, which would increase severity and possibly frequency. Both would be unpredictable, dependent on external factors such as the economy, and would thus introduce additional uncertainty into the reserving process.

There can be other claim development impacts, which while the financial impact is small can cause claims development distortions. For example, when customers call to report a claim they may realise their claim is below their excess and not proceed, but an online reporting tool may not alert them to this prior to submitting the claim. In both circumstances there will be no claim paid, but if submitted online a claim may be reported and will affect the nil claim frequency.

Increased use of profit share arrangements

Profit share arrangements may incentivise the broker to direct more business to the insurer. Adjustments need to be made to reflect this in a capital model; otherwise the model might overstate the underwriting result.

One way to reduce the impact of catastrophic losses is to write business in a wide range of geographical locations and across many classes. Catastrophe reinsurance will also help (more of this later in the course).

Latent claims

Claims can result from sources that were unknown, or for which a legal liability was not expected, at the time of writing the business. The expected cost of such claims cannot be calculated with any accuracy for the purpose of setting reserves.

The first problem with latent claims is that it is impossible to know where the potential claim is lurking. Secondly, if the claim does materialise, the future claim cost is very uncertain.

For example, will there be future employers' liability claims for damage to people's eyes from using computers too much? If so, how much will the claim amounts be, and how many people will be able to claim?

Judicial decisions can significantly affect the extent of an insurer's liability for these claims. For example:

- one court judgement can act as a precedent for other similar claims
- a single court judgement can apply retrospectively over many policies
- court award inflation is often significant.

3.4 Claims inflation not as expected

Inflation assumptions will often be required; for example, for calculating an initial loss ratio for the Bornhuetter-Ferguson method.

The Bornhuetter-Ferguson method is discussed further later in the course, although it should be familiar to you from your earlier studies.

Uncertainty regarding future rates of inflation, and in particular the rates of escalation of claims, will affect the assessment of the financial outcome of the existing business and hence the reserves required.

The actual inflationary experience will be a determinant in whether the chosen reserves are too high or too low.

3.5 New distribution channels

Different distribution channels will have different expense profiles.

Question

Comment on whether the main expenses are fixed or variable for:

- broker sales
- internet sales.

Solution

Broker sales may have a high variable cost and a low fixed (setup) **cost.**

This is because commission is incurred every time a policy is sold.

Internet sales may have a high fixed cost, *ie* setting up and testing the website, **and very little variable cost.**

The expenses for new distribution channels, including the set-up costs, will be far less certain than those for existing channels.

Commissions paid to brokers and other intermediaries are usually expressed as a percentage of the premiums payable, so can be fairly straightforward to estimate for business planning purposes, based on expected business volumes. Other expenses are less straightforward to estimate, giving rise to greater uncertainty, *eg* underwriting costs will depend on the level of, and time spent on, underwriting.

It may be difficult to predict the expense profile of a new distribution channel.

Set-up costs of a new channel must also be factored in.

Expense uncertainty also arises through a change in the relative proportions of business coming from existing distribution channels.

If the mix of sales differs from what was expected (either by class, distribution channel or broker), so that a higher proportion of business is sold on higher commission terms, the average commission rate will increase. Hence, uncertainty over the future mix of sales can give rise to added uncertainty when estimating future commission payments.

Additionally, where a differential rate of commission is paid on business acquisition to that paid on renewal, there is a persistency risk in the spreading of these different commission rates across future 'level' premiums. This applies equally to any business expense which is higher at the point of policy acquisition and initial processing than it is at the renewal stage.

A further risk or uncertainty may relate to the recovery of commission on a policy proposed but subsequently not taken up, or on early lapse where the distribution agreement specifies a return of commissions paid.

3.6 Planned or unplanned changes in mix

If the mix of business changes significantly, either as a result of the company pursuing a particular strategy or through unknown causes, the development pattern is likely to change, and in an unpredictable way.

8 Interactions with the claims department

As part of the reserving process, it is important for the reserving actuaries to have regular discussions with the claims department to ensure they are aware of key uncertainties in the data they are provided and anything the claims team are aware of but is not reflected in the claims data.

8.1 Allowances for claims monitoring activities for large losses

A key area that should be discussed with the claims team are any claims that are under close monitoring, but where the case reserve may not be representative of the likely claims cost. This is often referred to as a claims watchlist, but insurers may have different internal terminology for the lists of claims being monitored.

Some reasons that claims may be on such a watchlist are:

- **significant uncertainty in the claim value, for example a D&O claim where a formal claim has yet to be made but the claimant has notified the insurer of a possible claim**
- **a need to avoid legal prejudice, for example in a jurisdiction where setting up a case estimate could affect the court decision on the settlement value**
- **the insurer is not the lead insurer for the claim and its claims team takes a different view on the claim value from the lead insurer.**

Holding additional IBNR within reserving estimates for such claims is relatively common in the London Market. The metrics provided by the claims team vary but may include a most likely claim value or a worst-case outcome. Some claims teams may assign probabilities to different values or categorise claims (*eg* low, medium or high risk), which allow actuaries to more easily apply analytical techniques to the data.

While estimates of claims may be provided by the claims team, it is important for the reserving actuary to discuss these with the claims team and consider the risks in the context of the IBNR projected through actuarial techniques to ensure the estimates being recommended do represent a best estimate.

Reserving actuaries should consider the materiality of these losses and whether there is sufficient IBNR to cover the emergence of the losses rather than simply adding the value of the claims to the projected IBNR. Typically older years will have lower projected IBNR and so are more likely to need additional IBNR to cover these claims.

This is also an important consideration for long-tailed classes where experience early on may look particularly favourable or adverse, which can support reserving decisions to move a selection away from an initial expected loss ratio earlier than usual to reflect experience. The experience emerging could be driven by the mix of claims with case estimates held and being monitored.

Reserving actuaries should also consider whether the development patterns being used already allow for the timing of losses moving from monitoring to case estimates; if so there may be less need for the IBNR to be adjusted. If the development patterns rely on benchmarks, or portfolios are not consistent over long periods of time, this is unlikely to be the case and consideration of watchlists becomes more important. Even where there is a long period of consistent history, it is important to discuss with the claims team to understand if any of the claims are particularly unusual compared to the historical experience or the approach to monitoring has changed over time.

It can also be beneficial to understand the circumstances of particularly uncertain claims, for example those where claims will either settle for nil or at policy limits, so the reserving actuary can communicate uncertainties in the estimates presented. This can also be helpful in forming scenarios to present to management.

If these watchlists have been maintained over time, actuarial analysis of how claims emerge from the monitored list to case estimates can be helpful in understanding trends and accuracy of estimates provided.

8.2 Allowances for claims trends

The reserving actuaries and claims team should work collaboratively to share findings and understanding of emerging trends.

It is important for the reserving actuaries to understand the trends being observed by the claims team and in particular any actions that are being taken so the impact on triangles and reserving data can be understood. This could be numerical impacts, for example, strengthening the reserving basis in reaction to a number of adverse settlements; or anecdotal observations, for example, market trends on claim frequency starting to change.

Information sharing should work both ways, the aggregated methods for reserving can spot trends that are less easily observed at the granular level where the claims team tend to work, so sharing reserving observations can help the claims team in focusing efforts. It can also be helpful for the claims team to be able to explain the reasons for trends that are being observed.

8.3 Communicating uncertainties in the reserves

Discussions with the claims department can be helpful to explain key uncertainties in the reserving and create scenarios that are more realistic or plausible in the context of the business.

This could include for example selecting an inflation rate to use for a scenario where claims inflation is higher than currently assumed, or looking at the impact of open claims settling for the worst-case scenario on a run-off portfolio.

Chapter 14 Solutions

14.1 Factors that will influence the choice of valuation method and assumptions include:

- the purpose of the valuation, *eg* statutory or internal accounts
- the class of business, *eg* more margins for long-tail, liability business
- the size of the solvency margin, *ie* companies with very large margins may be relaxed about using strong bases
- quality, amount and stability of data.

14.2 (i) ***Purposes for which to estimate liabilities***

- to determine the liabilities for the insurer's published accounts
- to determine the liabilities for accounts that are used for the supervision of solvency
- to determine the liabilities for internal management accounts, business plans and budgets
- to estimate the cost of claims incurred in recent periods as an intermediate step in the rating process
- to value the insurer for purchase or sale
- to provide an independent opinion on the reasonableness or adequacy of the reserves booked by the insurer
- to provide information to management as to how areas of the business are performing
- to negotiate a commutation
- to transfer a book of business
- to ascertain the tax liabilities of a general insurance provider

(ii) ***Bases likely to be used, with reasons***

- Published accounts – going concern basis, true and fair view, best estimate and/or discounted basis. It depends on whether the insurer is using IFRS 4, IFRS 17, Solvency II, UK GAAP, *etc.*
- Solvency supervision accounts – discounted best estimate plus a risk margin under Solvency II. In some territories outside the EEA (European Economic Area), a prudent basis may be used, to protect policyholders. Will depend on the applicable regulation.
- Internal management accounts – basis will be agreed with management. Likely to be a best estimate basis in conjunction with sensitivity testing, to give a realistic view of the financial condition of the company.
- Rating process – realistic basis, often different to reserving basis and likely to relate to different (*ie* future) periods of exposure. A prudent basis could lead to the premiums being set too high while an optimistic basis could lead to the premiums being set too low. We don't want implicit margins in the premium rates.

- Purchase or sale – the liabilities as shown on the balance sheet is likely to be the starting point for negotiations. However, the seller might want to use an optimistic basis and the buyer might want a prudent basis. The final basis will depend on the relative bargaining power of the two parties.
- Adequacy of previous reserve estimates – often no estimation is needed since we are comparing actual paid claims with those expected by previous estimates. If we are analysing incurred claims, then it makes sense to use the same basis as that used in the previous reserve estimation exercise in order that a meaningful comparison can be made.
- Information for management – best estimate basis, to give a realistic view. We will also be interested in the sensitivity of the results, so we will use several different bases, for example worst case scenarios.
- Commutation – similar to purchase or sale, but will also want to consider any reinsurance recoveries, the importance of the commutation and the financial strength of both parties.
- Transfer of liabilities – similar to purchase or sale but will also need to consider any local regulations.
- Tax purposes – will depend on tax regulations in the relevant country, will need to ensure there is no excessive over-reserving and hence deferral of tax liabilities.

14.3 The assumptions for the calculations for the published accounts will need to take account of the legislation and accounting principles governing the preparation of those accounts in the territory concerned.

Consideration needs to be given as to:

- whether the accounts need to be prepared on a going concern basis
- whether the accounts are required to show a true and fair view
- the level of prudence required in the estimates …

  … for example, it is likely that the accounts need to be produced on a fair value approach, in which case a best estimate basis may be required
- whether reserves are required / allowed to be discounted and if explicit risk margins need to be held.

For the internal management accounts, discussions should be held with the management as to the required strength of basis.

It is likely that a best estimate basis will be used, in order to give a realistic view of the business.

Management are likely to want sensitivity testing to be carried out in order to understand the impact on the results of changes to key assumptions, *eg* claim frequency and claims inflation.

14.4 The most common purposes include:

- to determine the liabilities to be shown in the insurer's published accounts
- to prepare separate accounts for the purpose of supervision of solvency and to determine the liabilities to be shown in those accounts, if necessary
- to determine the liabilities that we show in the internal management accounts
- to value an insurer for purchase or sale
- to assess the adequacy of the company's case estimate and/or IBNR claims reserve estimation in previous year-end exercises
- to provide information to management on how areas of the business are performing, and provide an indication on the profitability of business currently being written
- to compare best estimates against held reserves
- to calculate ranges of results
- to transform an underwriting year into an accounting year
- to calculate movements in reserves and analyse reasons for these
- to calculate reserves in order to estimate the cost of claims incurred as an intermediate step in the premium rating process.

14.5 (i) ***Best estimate basis***

The best estimate is normally defined as the actuary's view of the mean or expected value of the eventual outcome. [1]

(ii) ***Why two actuaries may have different views***

It is difficult to ascertain the mean of the outcomes with a high degree of certainty and this can lead to differences. [1]

The best estimate calculation will be based on an actuary's subjective views. [½]

The best estimate calculation will reflect the mean of the possible outcomes considered and one actuary may include more possible outcomes than another. [½]

Each actuary will need to make it clear what he/she has allowed for in their derivation of best estimate. [½]

Different views could also be the result of:

- the use of different data [½]
- the use of different models / assumptions [½]
- errors in the model / data [½]
- the calculations being carried out at different points in time. [½]

[Maximum 4]

14.6 To select the discount rate, you would:

- consider the assets backing the technical reserves for the class [½]
- estimate the expected annual rate of return from these assets … [½]
- ... over the term of the liabilities ... [½]
- ... on a basis that is consistent with the assumptions for inflation [½]
- consider allowance for taxation [½]
- remove prudence from the estimated reserve, assuming that the rest of the basis makes suitable explicit allowance for contingencies (*eg* possibility of latent claims). [½]

[Total 3]

5 Analytical methods

5.1 Specifying distributions

The first step in estimating the variability of reserves is to formulate a statistical model by making assumptions about the underlying process generating the data. We can attempt this by specifying distributions for the data or just specifying the first two moments.

Distributions which might be used to model claims amounts or claim numbers include:

- **over-dispersed Poisson (ODP)**
- **negative binomial**
- **normal approximation to negative binomial**
- **lognormal.**

Once we have specified the distribution of either the incremental or cumulative claims, we fit the parameters.

The normal approximation to the negative binomial has the advantage that it can handle reductions in claims (for example, savings in incurred claims due to reductions in case estimates or salvage and subrogation) when modelling incremental claim amounts.

Question

Define 'salvage' and 'subrogation'.

Solution

You may often hear the two terms discussed side by side, although they are in reality very separate concepts.

Salvage: Amounts recovered by insurers from the sale of insured items that had become the property of the insurer by virtue of the settling of a claim.

Subrogation: The substitution of one party for another as creditor, with a transfer of rights and responsibilities. It applies within insurance when an insurer accepts a claim by an insured, thus assuming the responsibility for any liabilities or recoveries relating to the claim. For example, the insurer will be responsible for defending legal disputes and will be entitled to the proceeds from the sale of damaged or recovered property.

The Mack model is an example of a method that specifies the first two moments. It is effectively distribution-free as further assumptions are made with respect to the claims process, rather than an underlying distribution. We discuss this method in more detail below.

Many analytical methods are based around the chain ladder method, with the result that the mean outcome matches that derived by a standard chain ladder. This also means we are modelling the claim development triangles and therefore data needs to be structured in this way to be modelled.

The Mack model enables us to calculate the prediction error. That is, we estimate the process and estimation error together.

Most of the analytical methods focus on the mean and variance of the distribution of outcomes. It is often very difficult to obtain the full distribution. We usually make approximations for communication purposes. For example, a commonly used assumption is that the full distribution is a log-normal distribution with a mean and variance as calculated. It is then a simple task to calculate and present any percentile figures and produce a graph of the full distribution.

It is important to communicate the model error risk involved with such an approach.

5.2 Mack model

The Mack model was proposed by Thomas Mack in an academic paper published in 1993.

The best-known analytical model is the Mack model. The Mack model reproduces chain ladder estimates and makes limited assumptions about the distribution of the underlying data, specifying the first two moments only.

The key assumptions are that:

- **the run-off pattern is the same for each origin period (as for the chain ladder)**
- **the future development of a cohort is independent of historical factors (*eg* high factors in one period do not imply high or low factors in the following period)**
- **the variance of the cumulative claims to development time t is proportional to the cumulative claims amount to time $t-1$.**

The model produces standard errors for both individual origin periods and for all periods combined. The formulae required for deriving the Mack standard errors are quite straightforward to implement in a spreadsheet. The analytic formulae for the Mack model gives the mean square error of prediction (MSEP) of the chain ladder estimate of the claims reserve for each individual origin period and the total reserve over all origin periods.

As we mentioned earlier, the Mack model uses the past claims data to derive estimates of the mean and variance of the total ultimate claims arising from each origin period. The standard errors are the square roots of the estimates of these variances.

The Mack model is distribution-free, in that no distributional assumptions are made, only assumptions about the first two moments. As with many other analytical methods, however, a full predictive distribution is not derived, although we often approximate this by fitting a log-normal distribution with the same mean and variance.

Question

Suggest why a log-normal distribution might be appropriate here.

Solution

The log-normal distribution is skew with an extended upper tail. For many classes of business, this more accurately reflects the shape of the loss distribution then does a symmetrical distribution, such as the normal distribution.

It is important to keep in mind that the non-parametric estimation of mean and variance and often arbitrary choice of distribution makes this method particularly vulnerable to producing inaccurate results at the extreme ends of possible outcomes.

'Non-parametric estimation' in this context simply means that the Mack model does not assume a distribution about the underlying data.

The Mack model can handle negative claim increments, as are commonly found within incurred claims data, although problems may exist when data is very sparse.

For example, the formula for the variance will break down if very large negative increments cause the *cumulative* claim amount to be negative at any point.

Further detail for the interested reader can be found in Section 4.1 of the 2016 PSRWP paper.

5.3 Over-dispersed Poisson model

A Poisson model can be used to derive claim number distributions that produce the same results as using the Chain Ladder method. However, this is limited in that it can only generate non-negative integer values and has a variance equal to the mean.

The over-dispersed Poisson (ODP) model is a generalisation of the Poisson model, which overcomes many of the limitations of the Poisson model while retaining the same basic structure and the desirable feature that the reserve estimates are identical to those obtained using the Chain Ladder method.

The ODP and Mack models give exactly the same estimates of the reserves that would be produced using the chain ladder method. However, they are distinct models and give different estimates of the mean squared error of prediction (MSEP).

The key assumptions of the ODP model are that:

- **the run-off pattern is the same for each origin period (as for the chain ladder)**
- **incremental claim amounts are statistically independent**
- **the variance of the incremental claim amounts is proportional to the mean**
- **the expected incremental claims are positive for all development periods.**

Further detail for the interested reader can be found in Section 4.2 of the 2016 PSRWP paper.

5.4 Merz-Wüthrich formula

For certain applications such as reserve risk estimation for Solvency II capital modelling, it is necessary to obtain an estimate for reserve uncertainty over a one-year time horizon. This risk can be measured by estimating the uncertainty surrounding the claims development result (CDR), which is the difference between an estimate of the undiscounted ultimate claims cost made now, and an estimate made in a year's time, taking into account the claims development and emergence of new information during the year.

The CDR can therefore be thought of as the profit (or loss) in the reserves over a one-year time horizon.

One approach for estimating the reserve uncertainty over a one-year time horizon is to use the Merz-Wüthrich formula, described in Section 4.6 of the book '*Claims Reserving in General Insurance*' by David Hindley or in Section 3.1 of the 2020 PSRWP paper.

The Merz-Wüthrich formula is developed within the Mack model and is used to calculate the MSEP of the one-year CDR for each individual origin period and for the total CDR over all origin periods.

The Merz-Wüthrich formula is an analytic approach and so does not rely on simulation. Essentially, it uses the same assumptions as the Mack model, except that it considers uncertainty over a one-year period, whereas the Mack model does so over the lifetime of the liabilities. It is therefore effectively a one-year equivalent of the Mack model. Its close relationship to the Mack model also means that it can be implemented in the same spreadsheet or programming framework as the Mack model.

Without adjustment, the method does not include the functionality required to include a tail factor and only produces an estimate of the uncertainty surrounding the CDR, as opposed to its full distribution.

6 Simulation methods

Most analytic methods do not derive a full distribution of outcomes.

Usually they just give the mean and variance of the distribution.

In contrast, we can use simulation methods such as the Monte Carlo method to obtain predictive distributions of reserves. Although we do not derive the full mathematical form of the distribution, we obtain sufficient information (such as percentile tables and frequency plots) to communicate results.

6.1 Introduction to bootstrapping

A simple yet very powerful simulation method is to use *bootstrapping* techniques. Bootstrapping involves sampling (with replacement) multiple times from an observed data set to create a number of pseudo data sets. We can then refit the model to each new data set and obtain a distribution of the parameters.

Bootstrapping is a generic process that we can apply to a wide range of statistical problems, provided the model is well-specified.

Here is an example (not based on general insurance) to illustrate the idea behind bootstrapping. The word 'bootstrapping' is taken from the seemingly impossible task of trying to lift yourself up by your own bootstraps (shoelaces). This method appears to derive additional information about the statistical properties based only on the data itself, which might at first sight seem to be an impossible task.

Example

You own a portfolio of UK shares and the recent turmoil on the stock markets has made you wonder about the average return you might get over the next 10 years.

Describe how you could 'bootstrap' the data for the past 25 years of returns on the FTSE 100 index to estimate the distribution of the average return over the next 10 years.

Solution

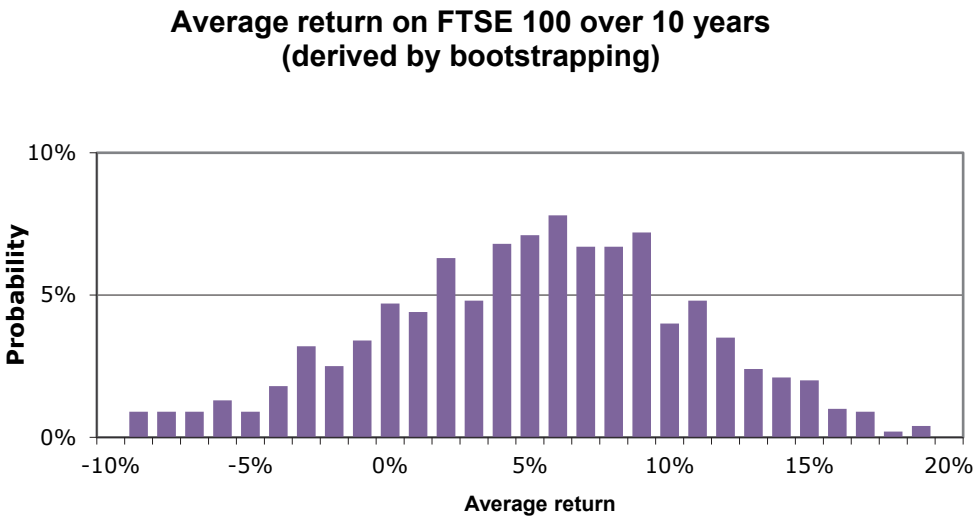
You could go through the following steps:

1. Get the past returns for 25 years (*eg* 1993 = 20%, …, 2017 = 8%).
2. Select 10 different values at random from this set of 25 numbers (allowing repeats), to represent a simulation of the returns for the next 10 years.
3. Calculate the average return based on this sample of 10.

   So you might get:

   Year 1 = 4%, Year 2 = 12%, …, Year 10 = –10% $\Rightarrow$ Average = 7%.
4. Repeat steps 2 and 3 another 999 times.
5. Draw a bar chart with the results of your 1,000 calculations from step 3.

The results might look something like this.



So we have bootstrapped the past data to find the distribution of the average return over the next 10 years. We could use this distribution to work out confidence intervals and the 'value at risk' over this period.

6.2 Bootstrapping a generalised linear model

It is important to realise that bootstrapping is not a model, it is a procedure applied to a model. It would be equally possible to bootstrap a generalised linear model (GLM), or Mack's model, or come to that, many other types of model.

With regression-type problems (and GLMs), the observations are not identically distributed because the means (and possibly variances) depend on each data point. So for these problems, it is common to bootstrap the residuals rather than the data points themselves, because the residuals are often assumed to be approximately independent and identically distributed.

Therefore the steps that should be followed when bootstrapping a GLM would be:

1. Define and fit a GLM, obtaining parameters and fitted values for the observed data. This should be familiar to you from your previous studies.
2. Calculate the residuals of your fitted model.
3. Take a sample from the residuals (this is the 'bootstrapping bit'), and invert these to obtain a set of pseudo-data.
4. Refit the GLM using this pseudo-dataset, to obtain another set of parameters for the model, and another forecast output.
5. Repeat steps 3 and 4 many times to derive a forecast output for each pseudo-dataset. This gives a distribution of parameters and outputs.

6.3 Bootstrapping the ODP model – the theory

The term 'bootstrapping' in the context of claims reserving is often used to refer to bootstrapping the ODP model although students should note bootstrapping is a broader technique and can be used for other models.

You may recall that a generalised linear model assumes that the data comes from the exponential family of distributions. One member of the exponential family is the over-dispersed Poisson (ODP) distribution.

The term 'bootstrapping the ODP' is widely used, and in essence it means that we are:

- fitting a GLM to the incremental claims data, using an ODP distribution as our underlying assumption
- then bootstrapping the residuals using the five-stage process above.

As with the analytical version of the ODP model, the method is based on modelling incremental claims on the assumption that they follow an ODP distribution (that is, that the variance is proportional to, but not necessarily the same as, the mean).

The key assumptions are the same as those from the analytical ODP model:

The assumption of positive incremental claims implies that the method is not always appropriate in cases where there are negative incremental claims. If negative increments are a genuine feature of the underlying business then it may be more appropriate to use a different model.

Question

Explain why this method would go wrong if there were negative incremental claims present.

Solution

Since the variance of the claims at each stage is assumed to be proportional to the mean (and the proportionality constant ϕ is positive), this can lead to negative estimates of the variance arising in some years.

Recall that negative incremental claim amounts are often a feature of incurred claim amounts.

A copula is a way of building a multivariate distribution such that dependencies of the underlying variables are represented. Some copulas require a correlation matrix to be specified (*eg* Gaussian copula and t copula) but others do not (*eg* Gumbel copula and Clayton copula).

Copulas are a more flexible (and complex) way of modelling multiple dependencies, rather than using single correlations.

The user must specify:

1. **Underlying loss distributions for the classes of business or origin periods.**
2. **A two-way correlation matrix between all distributions.**
3. **The form of the copula.**

The form of the copula describes how the copula links the underlying distributions. For example, a Gumbel copula (described further later in the course) gives a strong correlation between the tails and is also non-symmetric, making it suitable for many insurance applications.

It is usual to correlate the origin periods and lines of business separately to simplify the process of correlation.

The Core Reading below recaps a few forms of copulas. These are covered in more detail in an earlier subject.

The most commonly used form of copula is the Gaussian (normal) copula. This is often criticised for not giving enough dependency in the tail, and hence failing to model extreme events. Other copulas such as the Gumbel copula and t-copula remedy this.

The copula approach maintains rank correlation. In the case where the underlying distributions and copula are normal, the copula can maintain linear correlation. So, inputting linear correlation coefficients, *ie* Pearson product-moment correlation coefficient, will result in an output preserving these coefficients.

It can be difficult to parameterise dependencies from data; therefore, judgement is important.

8 Issues surrounding stochastic reserving

As with all methods, stochastic reserving methods are limited by the quality of the underlying assumptions. This section outlines some of the issues surrounding stochastic reserving.

8.1 Model forms

There can be mismatches between the type of model and the data to be used. The user should therefore take care to ensure the data is appropriate for the form of the model being used. A common limitation that restricts the use is negative increments in the claims data; some examples of the limitations this causes in different models are discussed below.

For example, for log-normal models we must ignore any negative increments (because we take the log of the incremental movements). Generally, this is not a problem for paid claims triangles (unless there are significant salvage or subrogation recoveries), but this method often does not work well for incurred claims data, where there are likely to be more instances of negative increments.

The ODP model is slightly more flexible because individual negative increments for any development period are possible, provided the development factor across the development period as a whole is greater than one.

The Mack model is very flexible in its model form because it allows negative increments and development factors less than one across a whole development period. However, while the Mack model can address this particular model form limitation, as with all methods that are based upon chain ladder methodology, it is unable to allow for calendar year effects and users should consider the limitations in the models being selected.

In some circumstances data adjustments can be made to address these problems.

8.2 Latent claims

The stochastic methods described above tend not to be suitable for certain types of claims, in particular latent claims, since they are only able to reflect the variability reflected in the claims data available.

A key feature of latent claims is that, by their very nature, we don't know how they are going to develop in the long run.

A possible alternative is to use an exposure-based method where assumptions are made about the volatility of the number of future claims, and the average cost of future claims.

In other words, we model the distributions of the claim numbers and the average claim amounts separately, and then combine them to find the distribution of the total claim amount.

The issue of latent claims and the fact that they are not reflected in past data are arguably part of a more general point about any different features not already reflected in the claims data and that the analytical methods will not capture this kind of variability.

This is discussed further in Section 0 below.

The variability estimated for the Mack and ODP models therefore does not always contain all possible sources of error, and so might give misleadingly low estimates of the variability.

The Mack and bootstrapping methods can only estimate variability based on the historical data available. Since the past data will inevitably not include *all possible* losses, these methods (and any other methods based on past data) will therefore underestimate variability.

8.3 Sparse data and data peculiarities

Sparse data sets are problematic for stochastic methods. While this is also problematic for best estimate reserving, in stochastic methods it is less easy to ignore them and supplement by actuarial judgement. Data peculiarities, such as missing or erroneous data, also cause problems in modelling. In particular, small changes in numbers can lead to significant changes in the distribution of outcomes. The results can be quite sensitive to individual data points.

Question

Explain how we could identify the extent of this problem.

Solution

We could apply some form of stress testing. For example, we could look at the effects of increasing or decreasing a few of the data values by 10%, or removing one or two data points. Alternatively, we could use a Monte Carlo (bootstrap) approach to create some pseudo data sets and then compare the answers.

Coping with individual data peculiarities is a matter of actuarial judgement. Judgement forms an important part of stochastic reserving, as it does for best estimate reserving. In certain smaller datasets, it may not be possible to produce credible outcomes from a stochastic reserving approach.

8.4 The extremes

For some purposes, we use stochastic reserving to determine the extreme tail of the distribution of possible outcomes.

However, we parameterise the distribution based on a finite amount of historical data, which may not be representative of the tail. In addition, in most stochastic methods we make some simplifying assumptions. These may be reasonable for the most central distribution of outcomes but may significantly break down at the extremes.

It follows that we should be especially careful when we estimate the tail of a claims distribution. This is particularly the case when considering large or infrequent events, for example modelling events not in data (ENIDs) or modelling IBNER for large claims.

For example, a normal distribution is likely to be a reasonable assumption in the centre of the distribution, but not in the tails.

8.5 Under-estimation of variability

There is consensus that many of the methods described here tend to underestimate the underlying variability of reserves.

For example, the central assumption of the Mack method of unchanged development patterns for different origin periods often does not hold in practice.

More generally, the historical data may not capture all sources of variability to which the reserves may be subjected in the future (*eg* potential changes in the Ogden discount rate, one-off increases in claims costs arising from court judgments, or a prolonged period of above average inflation).

When using the methods described here it is important to use judgement and not to accept the results of any one method without question.

8.6 Stochastic reserving in practice

As with deterministic reserving methods, an assessment of the reasonableness or validity of the results is an essential stage of the overall process of applying stochastic reserving methods before they are communicated to the interested parties.

For this reason, recent trends have seen a move towards scenario-based approaches to quantifying uncertainty as it is easier to communicate and can be tailored to show more tangible and real illustrations of uncertainty than can be achieved with stochastic reserving. Stochastic reserving remains heavily used within capital modelling as the distributions produced are necessary for the capital model.

The detail of any assessment will depend on the methods being used and the purpose of the exercise and is likely to involve the application of judgement and experience. Where the results are being used to estimate reserves at higher percentiles, *eg* 99.5th, then it is particularly important to validate the reasonableness of these results as they are generally less reliable than estimates at lower percentiles.

Most reserving software packages that include stochastic methods will include a range of numerical and graphical analyses to assist with the validation of the results.

Possible examples of the approaches used to validate the results include:

- reconciliation of stochastic results with deterministic results
- graphical review of results
- high-level reasonableness checks of numerical diagnostics
- comparison of results against benchmarks
- back testing of results
- applying stress and scenario tests.

Further detail is set out in Section 4.10.4 of the book '*Claims Reserving in General Insurance*' by David Hindley.

9 Alternative approaches

We will conclude this chapter by mentioning some alternative approaches that can be used for stochastic claims reserving.

9.1 The Bayesian approach

The Bayesian method is another important stochastic reserving method.

Recall that in Bayesian statistics the *prior distribution* (which captures our beliefs based on what we know of the exposure) is combined with the *likelihood* (which reflects the probabilities of the future claims development deduced from the past claims data) to produce a *posterior distribution*. The posterior distribution reflects the probabilities of the future claims development deduced from both the past claims data *and* our beliefs based on what we know of the exposure.

The key result from Bayesian statistics is the relationship:

$$\text{Posterior distribution} \propto \text{Prior distribution} \times \text{Likelihood}$$

A Bayesian approach can also be used for stochastic reserving. Under the Bayesian theory framework, the prior distribution of the model parameters is first chosen based on judgment or experience. Then the posterior distribution of the parameters variable is calculated using Bayes' Formula.

The choice of prior distribution depends on many factors including the way in which the model is parameterised. The parameter being considered may or may not have a natural interpretation.

In addition to the choice of prior distribution, the data used to parameterise and the choice of model will influence the resulting posterior distribution. By combining the prior distribution, data and model choice, the posterior distribution will contain more information than the underlying prior distribution.

Using simulation-based techniques such as the Markov Chain Monte Carlo (MCMC), a simulated distribution of parameters can be obtained. This approach is an alternative to bootstrapping to obtain the distribution of parameters (*ie* parameter uncertainty).

In other words, the two approaches will result in two different sets of model parameters. The choice of which approach to use can require significant judgement, and is an example of parameter uncertainty.

Note: the process variance still needs to be incorporated, which is done at the forecasting stage by simulating from the process distribution conditional on the parameters.

Advantages

One advantage of the Bayesian method is that it provides a complete predictive distribution of the ultimate reserve. For the other methods, even if the variance can be calculated, the closed form distribution is not available (bootstrapping can provide the parameters to simulate from).

Although this distribution from the Bayesian method depends on the chosen prior distribution, it does give more information. Many statistics, such as confidence intervals, quantiles or probabilities of extreme values, can be calculated from the complete predictive distribution.

Recall that the Mack model, for example, is distribution-free. It only predicts the mean and variance, not the actual shape of the distribution.

Another advantage of the Bayesian method is that it explicitly shows the impact of judgements, which is reflected in the prior distribution. For other methods, these judgements are usually implicitly made and it is difficult to evaluate their impact.

Similarly to the analytical method, the Bayesian method could give closed-form results when an appropriate prior distribution is chosen.

Recall that, in Bayesian statistics, there are certain natural combinations of distributions that arise, such as Poisson-gamma and normal-normal, where the posterior and prior distributions come from the same family of distributions. These are called 'conjugate' distributions. The posterior distribution in these cases is a 'closed-form' distribution, *ie* it can be described by a simple formula.

Disadvantages

Despite these advantages, the use of the Bayesian method in stochastic reserving is subject to the same criticisms as the Bayesian methods in general. In particular, the choice of prior distribution is subjective, and the posterior distribution may be over-reliant on the choice of prior distribution.

Other than this, the Bayesian method may not give closed-form results and numerical integration is needed to get results. However, great progress has been made recently in this area and the Markov Chain Monte Carlo (MCMC) method can be used to calculate the integration.

The MCMC technique is required when there is no simple formula for the posterior distribution. It is an iterative technique where repeated Monte Carlo sampling is used to obtaining increasingly accurate approximations to the posterior distribution.

An example of the general procedure in which Bayesian methodology is used in a stochastic reserving context is set out in Section 4.5 of the book titled '*Claims Reserving in General Insurance*' by David Hindley.

9.2 Other methods

In some circumstances, it may be necessary to estimate reserves in the absence of any past claims data, *eg* when a new line of business has recently been introduced.

Other methods which can also be used to understand the uncertainty of reserves include:

- **Use of cedant or market figures / reinsurers' expertise. However, these methods can only be used where comparable cover is already offered by other insurers, thereby providing a source of claims data.**

  Market data is published by organisations such as the ABI (the Association of British Insurers) in the UK.

- **Policy limits. Where materiality is not an issue or where time pressure prevents any significant amount of analysis being performed, policy limits provide an upper limit for the reserve that should be held. A more reasonable approach, however, is likely to be a proportion of the policy limits, where the proportion is determined by benchmarking or intuitive means.**

  Here 'policy limit' refers to the maximum claim amount that could arise under the terms of the policy.

  'Materiality' is an accounting term that refers to whether a particular item is financially significant (and therefore its value must be assessed accurately using an established method) or insignificant (in which case a rough estimate is acceptable).

- **Stress and scenario tests around the most significant assumptions and key areas of uncertainty.**

- **Intuition / professional judgement. Professional judgement is always a useful cross-check for an actuary, or other person carrying out the reserving, using any personal insight, views, beliefs and knowledge in order to produce an initial estimate for comparison with the other methods and actual experience over time. By looking at the differences between these estimates a much greater understanding can be gained.**

The chapter summary starts on the next page so that you can keep all the chapter summaries together for revision purposes.