Actuaries Institute Australia

LIFE INSURANCE AND RETIREMENT VALUATION

MODULE 5: LIFE INSURANCE LIABILITY VALUATION METHODS

Education Program
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Education that Counts

Fellowship Program

Module 5

LIFE INSURANCE LIABILITY VALUATION METHODS

Education that Counts

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5. Life insurance liability valuation methods

The previous module examined the different types of life insurance and retirement fund liabilities and considered the wide variety of reasons for performing a liability valuation.

This module explains the different valuation methods that are used by actuaries and how the context and reason for a liability valuation drives which methods are appropriate.

The methods and techniques covered in this subject are not specific to any particular jurisdiction but, rather, provide a basis of knowledge which can be applied and adapted to the specific laws and generally accepted actuarial practices within different jurisdictions. Application of these concepts in the Australian environment will be covered in depth in the subjects Life Insurance Applications and Superannuation and Retirement Applications. Valuations for defined benefit funds are covered in Module 9 (Valuation of retirement funds).

The learning objectives covered in this module are:

Item	Unit/Key Performance Objective/Learning Objective
3	**Prepare a valuation of life insurance or retirement fund liabilities**
3.3	**Suggest and evaluate an appropriate valuation method, model and actuarial basis for major insurance product lines and for retirement products**
3.3.1	Critique the principles guiding the selection of valuation approaches
3.3.2	Analyse various valuation methodologies, including cash flow projection versus formula, prospective versus retrospective, net premium versus gross premium, and stochastic versus deterministic
3.3.3	Distinguish between different valuation methodologies and consider the circumstances where each might be applied
3.3.4	Apply methodologies for calculating claims reserves for IBNR, RBNA and CICP/DLR
3.3.5	Develop models for the application of methodologies for major product types
3.4	**Distinguish between gross of reinsurance and net of reinsurance calculations and understand the credit risk associated with transfer of insurance risk**

5.1. Valuation approach

Broadly speaking, products are priced such that premiums receivable plus investment earnings are sufficient to cover expected benefit payments, initial costs, renewal costs and, if required, profit. In general, there is a mismatch between receipt of premiums, expenses incurred and payment of benefits. Product pricing is discussed in depth in the LI&R Product Development subject and our discussion here is limited to highlighting the components of a premium and why reserves are required.

Symbolically, we can equate premiums with outgoings using an equation of value:

premiums (P) * annuity factor = benefit (B) * assurance factor + initial expenses (IE)+ renewal expense (RE) * annuity factor,

where the investment earnings are implicitly in the factors and profit is ignored. The equation is formally true for all contract types that have level premiums throughout the contract duration but can be adapted to cover non-level premiums. Notation is being abused as the annuity factors on both sides are not the same factor.

Exercise 5.1

Amend the equation of value to represent a unit-linked contract (Hint: you may want to consider separate equations for policy owners and shareholders).

If we assume experience is exactly in line with the assumptions used when pricing a product, then at any time during the contract term, the value of premiums, past and future, equate to the benefits and expenses incurred plus future benefits and expenses.

The value of all the premiums at some time t after policy inception may be written as $(\ddot{a} + \ddot{s})$, where $\ddot{a}$ represents an annuity from time t and $\ddot{s}$ represents an accumulation up to time t. The value of $1 of benefits from time t may be written as A and the accumulated value of the cost of $1 of benefits incurred may be written as ${}_{t}k$.

The 'cost of insurance', ${}_tk$, may be thought as the value at time t of past implicit mortality charges, allowing for survivorship. For example, an expression for ${}_tk$ for a whole of life insurance, where death is payable at the end of the policy year in which death occurs, is $\frac{l_x}{l_{x+t}}(1+i)^t\, A^1_{x:t}$. The assurance function, $A^1_{x:t}$, is a t-year assurance function written on a life aged x at outset. Another way of thinking about this concept is to consider what happens in any policy year for the whole life contract. If the insured survives a policy year, then there is no benefit payable. However, insurance is a pooled concept. The expected cost in policy year n is Bq_{x+n}. If the portfolio has $(1/q_{x+n})$ lives, then the expected number of deaths is 1 and each policy contributes the expected cost. The costs each year need to be inflated to time t and the valuation is only on contracts in force so that survivorship must be considered.

We continue to abuse notation and use similar symbols for the expenses components, assume investment earnings are i per annum, and write the equation of value at time t as:

$$P(\ddot{a} + \ddot{s}) = B({}_tk + \mathrm{A}) + IE(1+i)^t + RE(\ddot{a} + \ddot{s}).$$

This may be re-arranged to equate the past with the future:

$$P\,\ddot{s} - B\,{}_tk - IE(1+i)^t - RE\ddot{s} = BA + RE\ddot{a} - P\ddot{a}\,.$$

The left-hand side is called the *retrospective reserve* and represents, in some sense, an accumulation of assets. The right-hand side is called the *prospective reserve*. It represents future claims and expenses on the company, net of future premium income. If no claim has been made by time t, then expected future premiums will be insufficient to pay expected future benefits and associated costs. Ignoring complications that will be discussed later in this module, a life company will need a reserve of assets (the left-hand side) to pay for its liability (the right-hand side). If the life company holds assets equal to the right- hand side and future experience is as expected then, obviously, averaged over a large number of similar contracts, the life company will have sufficient assets to pay for the liability.

The discussion above explicitly assumes that experience is exactly in line with unchanged assumptions. In practice, assumptions change, experience is never in line with what was assumed and there may be differences between assumptions for reserving and pricing. Thus, it is unlikely that the accumulation of past cash flows will exactly equal the future value of benefits and expenses, net of future premiums. However, it is generally true that the value of policy liabilities at a point in time usually involves estimating expected future cash inflows and outflows and the present value of those cash flows[1].

This is basically a discounted cash flow calculation, which we can formally write as:

$$Value = \frac{\sum[E(cash\ outflows\ at\ time\ t) - E(cash\ income\ at\ time\ t)]}{(1+i_t)^t}.$$

In life insurance, the timing and amount of such future cash flows are uncertain and can only be estimated. Similar considerations apply for retirement funds. This module discusses how the valuation of policy liabilities is calculated. The discount rates, i_t, are critical in calculating a present value and their determination is discussed in Module 8 (Assumptions).

The estimation (or valuation) of policy liabilities requires four key components: data, a valuation method, a basis and a model. Note that all components depend on the purpose of the valuation and on any legislative constraints. Valuation methods, bases and models are discussed in this Module. Data is discussed in Module 10 (Process).

- The **valuation method** refers to the particular valuation procedure. The method will state how the liability is defined. For example, one method may be defined by projecting and discounting all future cash flows and another method may be defined by accumulating past cash flows. It will also specify how cash flows are treated; specifically, whether an item is included or excluded.

[1] Some valuation techniques are retrospective and take a different, backwards-looking approach, which will be explained later in this module

- The **valuation basis** refers to modelling assumptions which may be both explicit (e.g. renewal expenses of 5% of premiums) and implicit (e.g. expenses assumed to occur at the same level as estimated when calculating the premiums payable under a particular contract). Assumptions are the modelling input variables that reflect the processes driving cash flows.

  A liability valuation involves the setting of assumptions related to future experience such as claims, premiums, investment earnings, expenses, taxes, and lapses. Assumptions are generally derived from the past experience of the business, split into broad product categories, but must be adjusted to allow for what is expected in the future. Assumptions also include economic factors such as interest rates, inflation rates and future investment returns, and legislative and environmental factors such as taxation. In almost any situation, there will be a range of reasonable assumptions that could be adopted and justified.
- The **valuation model** is the simplified representation of actual, but unknown, liabilities. It is the engine that generates the results. Models may be formula-driven (e.g. chain ladder method, commutation functions), deterministic or stochastic. The particular method drives the model input and calculations.

Example

Suppose a single premium unit-linked contract offers a return of premium on death. The company selling the contract does not explicitly charge for this guarantee. The purpose of the valuation is to estimate the cost of the death benefit.

The method required will project forward all relevant cash flows (value of the unit-linked funds, net of fees), determine if there is a death strain at risk at any future time (i.e. are there times where the premium exceeds the value of the unit-linked funds), estimate the cost of the death benefit by multiplying the death strain at risk by a suitable mortality decrement and discounting back to the valuation date.

The basis will be set using the most realistic parameters to determine the expected cost.

The model may be a stochastic model to represent the variability in the unit-linked funds. It will need to incorporate probability distributions and parameters as input assumptions. An alternative may be to use a formula representing put option costs on indices that closely represent the unit-linked fund performance benchmarks.

The term "**valuation approach**" can be used to collectively cover the valuation method, assumptions and model.

The terms *method*, *basis*, *model* and *approach*, as defined above, are not universally-agreed terms. Terminology is likely to vary between countries and each company may possibly have its own definitions. For example, *basis* sometimes refers to the set of assumptions *and* method rather than just the set of assumptions. The connection between *method*, *basis* and *model* may lead to some overlap in the uses of these terms. The practitioner should ensure that they understand how these terms are used in a particular context and be clear about their own usage in the work they perform. A general rule is to treat jargon with care and check that your intended audience understands what you mean when using it.

The following are key inputs into the selection of an appropriate valuation approach:

- **Purpose of the valuation:** This is of primary importance in the selection of a method. For example, a valuation may form part of a balance sheet prepared for public reporting purposes. This may require a more rigorous and detailed method than a monthly calculation of the liability required for internal management purposes.
- **Valuation standards:** Regulators may require a particular method and assumptions to be used for statutory reporting purposes. A published valuation will need to meet all regulatory requirements, including relevant accounting, prudential and professional standards. For example, a company preparing a valuation to be incorporated into the accounts of an overseas parent may need to consider regulations from multiple jurisdictions. Prudential regulations may be principles-based or rules-based, requiring specific assumptions or formulae to be applied in certain situations. Regulations may contain a mixture of principles and rules.
- **Products to be valued**: The products to be valued can influence the choice of method to use. For example:
  - a deterministic projection method selected to value a portfolio of individual term insurance policies may not be suitable to value a savings contract that offers an investment guarantee;
  - participating policies often need adjustments to be made to valuation methods as it is important to disentangle policy owners' interests and shareholders' interests;
  - some methods do not work with many of the types of savings contracts sold today. For example, the net premium method discussed below and in the Foundation course (Part I) is not applicable to unit-linked business.
- **Timing of profit release:** Different valuation methodologies will impact the timing of profits reported by the company. For example, a conservative valuation basis will tend to defer the release of profit compared to a more realistic valuation basis. This concept will be discussed further in Module 6 (Profit).

Exercise 5.2

Why is a deterministic projection based on best estimate assumptions not used to model variable annuities with minimum maturity guarantees?

It is important to note that future experience will only be known as it unfolds and is not affected by the valuation methodology, basis or model. The only certainty is that experience will be different to that assumed.

Setting a valuation approach is a matter of professional judgement. As will be discussed in Module 8 (Assumptions), different actuaries will have differing views as to the most appropriate approach to use for a given set of cash flows. There is not one single correct approach. Even two actuaries setting bases for the same purpose, using the same models, and with the same historical data available to them, may form different views as to what constitutes the most appropriate assumptions about the future. For example, they may each have different answers to the questions of "Will mortality rates increase or decrease in line with past observations?" and "What investment conditions are expected over the next five years and beyond?"

The following questions can be useful to guide an actuary in selecting an appropriate valuation approach:

- What are the relevant legislative standards that the valuation approach must meet?
- Are there relevant standards or documentation that need to be met for internal reporting purposes?
- How will the liability valuation allow for all material matters in relation to policy design, such as contractual benefits, policy owner options and reinsurance?
- How important is consistency in approach from one valuation to the next?
- How will consistency in approach between the valuation of liabilities and assets be allowed for?

    a. For example, where cash flows to be valued depend on future investment earnings, will the assumption for investment earnings reflect the expected investment earnings on the actual assets invested?

- Will the liability be valued using realistic, conservative or optimistic assumptions?
- Will the liability include margins for extreme events, either explicit or implicit?
- How will the valuation support a meaningful measure and analysis of surplus into key sources such as planned margins and experience variations?

  b. For example, under Australian standards, there must be a uniform emergence of planned profit, in line with a well-considered business metric such as earned premium.

- How will the valuation adequately reflect asymmetrical risks such as those created by policy options and guarantees?
- What practical issues exist, such as data reliability and implementation constraints? For example, how long will it take to run the valuation model compared to how quickly updated results are required?

As for any actuarial task, a professional approach involves documentation of the judgments, methodologies, bases and models applied, including any qualifications or limitations. This is critical so that an independent professional reviewer can understand the justification for the decisions taken. It's also important to document these aspects of a valuation for future reference within the valuation team; for example, for reference in subsequent valuations.

Exercise 5.3

Describe the steps you could take to ensure that your liability valuation includes all material matters.

Exercise 5.4

Explain why it is important to apply consistent approaches in measuring policy liabilities. You should consider consistency over time and consistency between companies.

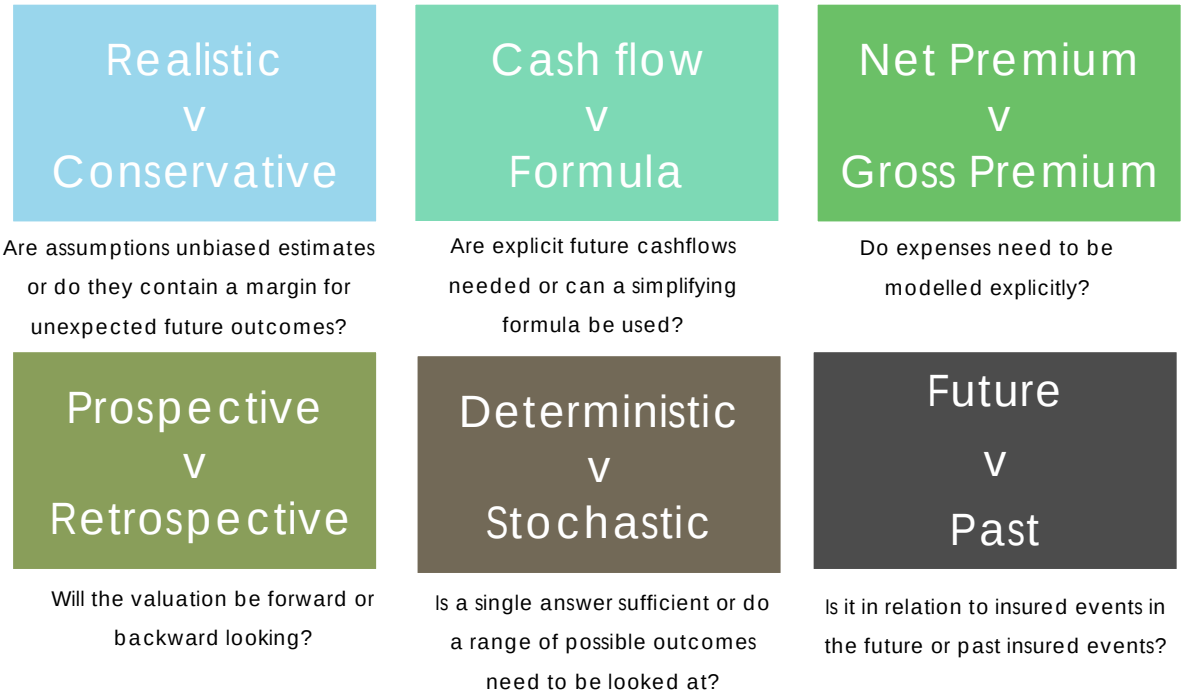
5.2. Valuation methodologies

The previous section listed the key considerations that guide an actuary in choosing a suitable valuation approach. These considerations include the purpose of the valuation, the relevant stakeholders or end users, and any requirements or constraints which apply. Once these have been considered, the actuary has options to choose from in selecting an appropriate valuation method.

There is a worldwide move to use a gross premium projection methodology with a realistic basis, as this aligns with worldwide accounting standards under development. However, it is important to understand the different methodologies and their usages, strengths and shortcomings, as older methods such as net premium projection methodology with conservative assumptions are still used for prudential reporting in some jurisdictions. Also, the purpose of this subject is to develop an understanding of why something is done, rather than what is required under a particular jurisdiction. Developing a process to question a method is important as legislation changes and new methods are introduced.

The main categories of methodologies in use are summarised in the following diagram and are described in the following sections of this module:

Figure 5.1: Liability valuation methodology options



The 'Future v Past' box relates to the timing on the insured events. Section 5.2 covers methods that value future insured events that have not yet occurred. Section 5.3. describes methods that estimate claims that may have occurred before the valuation date but either the company does not know yet know about the claim or has not accepted a submitted claim.

The following five subsections in this section address the remaining five boxes above but in a slightly different order. There are subsections covering 'Realistic v Conservative', 'Prospective v Retrospective' and 'Deterministic v Stochastic'. There are separate sections covering the net and gross premium methods, with the pros and cons of cash flow and formulas embedded into the text.

5.2.1. Realistic versus conservative

An important consideration in selecting a valuation methodology is whether the valuation is to be based on what the person responsible for the valuation expects to happen (a 'realistic' or 'best estimate' basis) or whether they deliberately over- or under-state the expected cash flows. A basis that places a higher value on liabilities than a best estimate basis is a *conservative approach*. A basis that places a lower value on liabilities than a best estimate basis is an *optimistic approach*.

The term *best estimate* is used extensively in accounting and regulatory standards throughout the world. *Best estimate* represents an unbiased estimate of the value of contingent liabilities. *Best estimate* is described in European Solvency standards as a probability-weighted average, or mean, where the estimation process is unbiased and based on all currently available information, including currently observable trends. The Australian regulator adds to the definition by including judgment and experience as components of the estimation process.

A realistic valuation of policy liabilities can be defined as the amount expected (under realistic assumptions) to be required to meet future benefits and future expenses for the business in force. These liability values are also referred to as "best estimate" liabilities.

Under a realistic valuation basis, the assumptions contain no deliberate bias. However, individuals often have unconscious biases and different actuaries will have different views on what the most realistic assumptions for the future are. While there is only one true (but uncertain) future outcome(s), there is no single, correct, realistic basis, and the assumptions selected will always rely on the professional judgement of the actuary making them. In practice, a range of different assumptions might all be realistic and justifiable and the actuary will select an assumption either at the top, middle or bottom of this range based on their experience and judgement. It is, therefore, important to document both the assumptions selected for a model and the reasons for selecting them.

A realistic valuation has no margin for adverse deviations from the underlying assumptions. That is, money set aside ("reserves") based on such a liability would be insufficient to meet future obligations under many scenarios, such as when insurance claims are higher than expected or investment earnings are lower than expected. In particular, if distributions of outcomes are symmetrical, reserves based on realistic valuations would be insufficient 50% of the time. Without further margins, realistic values would not be suitable for a valuation to demonstrate prudential capital adequacy (i.e. the ability to pay all obligations as they full due, even under adverse scenarios). Life companies using realistic valuations are generally required by regulators to hold additional shareholder equity or capital. This concept of prudential capital adequacy will be covered in Module 14 (Capital).

One advantage of using a realistic approach is that any margins for conservatism are explicit and easier to quantify. This means that prudential capital adequacy margins can be targeted to a specific level of statistical sufficiency. Similarly, profit under a realistic basis can be easier to analyse and understand. The impact of the valuation basis on profit is covered in Module 6 (Profit).

The valuation basis can reflect varying degrees of optimism or conservatism regarding expected future experience. Depending on the purpose of the valuation, it may be desirable to take a more conservative view which would lead to higher liability values, or a more optimistic view such as when valuing liabilities as part of a potential acquisition, which would lead to lower liability values. The amount of "conservatism" is sometimes referred to as the "strength" of a valuation basis. The more conservative, the stronger the basis.

A conservative valuation basis is one where valuation assumptions are deliberately more pessimistic than expected. An example would be the addition of a 10% loading over and above expected claims costs as a contingency. When liabilities are valued on a conservative basis, there is a greater degree of certainty that future obligations will be met.

Historically, liabilities were often valued on a conservative basis, with implicit margins built into assumptions so that companies could meet their obligations even in more adverse circumstances. If a conservative valuation basis is used, the one valuation may be considered suitable for both general purpose reserving or reporting and for prudential capital adequacy margins. However, profit results using a more conservative valuation basis may be considered less meaningful and would be more difficult to explain, with surplus generated in a period not being a true estimate of underlying profit. Module 6 (Profit) will expand on this concept further.

It is important to again emphasise that professional judgement is always required in the selection of assumptions and analysis of experience on which assumptions are based. Different professionals may independently derive a different set of realistic, conservative or optimistic valuation assumptions, depending on their view of the future. Therefore, a liability (whether best estimate, conservative or optimistic) should not be considered as the one correct value. Rather, it represents one of a range of possible values that might be determined for the particular obligations under consideration. This is an important concept that actuaries must communicate well when providing valuation results to the end user.

5.2.2. Gross premium liability

Method

The term *gross premium* is merely another name for the premiums payable, also known as the *office premiums*. These premiums are determined to cover benefits, expenses and, where relevant, profit.

This method appears quite natural as the gross premium liability is defined as the present value of future outgo (benefits and expenses) less the present value of premiums payable.

For example, a life company will determine a value of a non-profit term assurance contract at the valuation date provided that the contract still exists at that date. A condition for the contract to remain valid is that premiums are paid when due. For a valid contract, the company promises to pay the agreed sum assured if the nominated life insured dies before the contract end date. Thus, the liability for this term assurance contract is the present value of the future benefit less the present value of the premiums payable. It seems reasonable to allow for the assumed expenses of managing that contract. Thus, the gross premium method looks like a sensible choice.

The method allows explicitly for all outgo and for the future receipt of the actual premium payable. It also utilises, where appropriate, the known sum assured, declared reversionary bonuses, and assets. The consistency of assets and liabilities is discussed in Module 11 (Assets).

The gross premium approach can be used for all types of policies, with some modifications.

A significant modification is with both unit-linked business and investment-linked business. These contracts are valued using a combination of the gross premium method and an accumulation method (see Section 5.2.6).

Basis

As all items of inflow and outflow are valued, the basis for the gross premium liability will require assumptions on all cash flows. However, some items may be ignored as immaterial or not acceptable when calculating prudential liabilities.

Exercise 5.5

List the basis assumptions in relation to valuing a participating endowment assurance.

Best estimate assumptions are likely to change in line with changes in experience, particularly with changes in economic conditions. Bases that change as experience develops are known as ‘active’ bases. The gross premium liability is usually associated with an active basis, although not necessarily a best estimate basis.

The valuation is sensitive to a change in basis as the actual premiums in respect of in-force business are obviously unaffected when valuation assumptions are changed. Any changes in assumptions are capitalised at the valuation date.

The gross premium valuation using a best estimate basis fits well with the concept of profit emerging each year. This is explained in Module 6 (Profit). However, the confidence interval for the best estimate gross premium valuation is too low for prudential capital adequacy purposes. That is resolved these days in many jurisdictions by investigating more severe scenarios as discussed in Module 13 (Risk management) regarding risk-based capital management. The gross premium liability method has some restrictions placed on it for prudential reporting in some jurisdictions although the alternative, the net premium valuation method discussed in the next section, is not as popular as it has been.

Model

There are two types of model: cash flow and formula.

A gross premium cash flow model will consider the timing of cash flows. The explicit modelling of future cash flows, as well as being used for the liability valuation, can be useful in business planning, asset management processes and model validation. Commercially available cash flow software packages have been commonplace in life companies for some time. Similar packages are also available for defined benefit retirement funds. The models may be deterministic or stochastic.

The gross premium cash flow model explicitly includes material contract features such as indexation of benefits and policy fees. Models are likely to explicitly include different types of expenses (initial and renewal commissions, initial costs, maintenance costs, and claims costs) as well as investment returns on reserves. Discount rates may vary by duration within a cash flow model.

Cash flows are not explicitly modelled in a formula approach. Commutation formulas developed in the Foundation course are used to calculate liability values.

Formula approaches can work for conventional business such as level premium term assurance and conventional participating business with compound bonuses. It is relatively cheap and easy to build a formula model to provide a quick answer or as a check on more complicated models.

Formula approaches, by definition, avoid the need for projection of future cash flows. They were widely used historically and were valuable in the days before computers or when computer resources were scarce and unable to perform detailed calculations in a timely manner.

Formula approaches have the limitation that they do not readily incorporate many complexities of life insurance policies, such as benefit indexation features, stepped premiums, benefit riders, reinsurance arrangements and loyalty premium discounts. Results under a formula method are presented as a single present value of future cash flows, with no information about the detailed yearly or monthly cash flow items underlying the valuation calculation. The results can therefore be difficult to explain and may seem artificial. As computing power has expanded, formula methods have become less important. They can, however, be useful as a check for reasonableness of valuation results produced by other methods. For these reasons, cash flow methods are now used in the majority of valuations in life and retirement valuations, rather than formula-based methods.

Example: Participating policy gross premium valuation

This example considers an annual premium whole-of-life assurance policy issued by a mutual life company to a life aged x exactly at issue. The initial sum insured of $B plus any attaching reversionary bonuses are paid at the end of the policy year when death occurs. Assume the life company declares a compound bonus of b each year and the policy year coincides with the date that annual reversionary bonuses are declared.

If we ignore the extremely important lapse decrement, the equation of value is:

$P\ \ddot{a}_x^{(i)} = IE + RE\ a_x^{(j)} + TEA_x + \frac{B}{1+b}\sum_{t=0}^{\infty}(1+b)^{t+1}\ v^{t+1}\ {}_tp_x\ q_{x+t} = IE + RE a_x^{(j)} + TEA_x + \frac{B}{1+b}A_x^{(k)}$,

where:

RE is the Renewal Expense

TE is the Termination Expense

$a_x^{(j)}$ is calculated at a rate $j = \frac{1+i}{1+inf} - 1$, where *inf* represents the inflation of the renewal expense;

$A_x^{(k)}$ is calculated at a rate $k = \frac{1+i}{1+b} - 1$.

The LI&R Product Development subject will elaborate on how to determine the pricing assumptions and discuss other factors that affect the price.

The premiums contain an allowance for future declared bonuses, initial expenses and expected future expenses. The jargon is that the premium is 'loaded' to pay for those costs. In particular:

- each premium contains an allowance of $\frac{IE}{\ddot{a}_x}$ to pay for the initial expense, and hence, initial expenses are 'recovered' over the life of the contract.
- each premium contains an allowance of $RE\ a_x^{(j)} / \ddot{a}_x^{(i)}$, indicating that the early premiums have excess renewal cost loadings;
- each premium contains an allowance of $\frac{B}{1+b}A_x^{(k)} / \ddot{a}_x^{(i)}$, indicating that the early premiums have excess death cost loadings.

If the gross premium valuation did not allow for future expected bonus, then the liability would be too low. The liability must, therefore, include an allowance for future bonuses. This leads to the name *bonus reserve method* as an alternative to *gross premium method* which is used when valuing conventional participating business.

Exercise 5.6

Why would the liability be too low if there was no allowance for future expected bonus?

The liability at time t, immediately after a bonus declaration, is:

$$ {}_tV_x = CA^{k}_{x+t} + RE' a^{j}_{x+t} + TE' A_{x+t} - P\, a^{i}_{x+t}, $$

where the commutation functions are based on the valuation assumptions, which are not necessarily the same as the premium assumptions.

- the factor *C* represents the past history of bonus declarations, which may not have been a uniform declaration of *b* each year;
  - if a uniform bonus of *b* had been declared at each declaration, then *C* would be equal to $B\,(1+b)^{t-1}$;
- the best estimate assumptions about the future (as at the valuation date) may not correspond with the best estimates when the premiums were set:
  - the allowance for future expenses, *RE'* and *TE'*, and any inflationary element, are not necessarily the same as the allowances *RE* and *TE* in the premiums P;
  - the allowance for mortality in the assurance and annuity commutation functions may be different than those in the premium assumptions;
  - the valuation rate of interest may be different than that contained in the determination of P;
  - taxation may have changed.

When a part of the valuation basis changes, the effect is not spread over the remaining term of the policy but is captured immediately. The effect of the change is capitalised at the valuation date. Also, any differences between the premium basis and the valuation basis are capitalised at outset. Small changes in assumptions may create a disproportionate change in the liability unless an offset is made to the assumed future uniform bonus rate.

A criticism of this method relates to the concept of Policy owner Reasonable Expectations (PRE), which was discussed in the Core Actuarial Management subject (Control Cycle). The contractual terms between the life office and the policy owner do not guarantee a defined rate of bonus but, rather, the right to receive a distribution of surplus in a specified form. The bonus reserve valuation will place a liability on the balance sheet equal to the assumed future declared bonus. This may create an expectation that may tie the company to declaring a uniform bonus rate. Management of participating business is discussed in detail in the LI&R Product Development subject.

5.2.3. Net premium liability

The net premium liability is defined as the present value of the future benefits less the present value of net premiums payable, where the net premium is calculated using the valuation basis.

The net premium is defined as the value of premiums, allowing for the contracted frequency and term of payment, that equals the value of benefits. No allowance is made for expenses or future profit and, hence, the net premium will be lower than the actual premium charged (the office premium), assuming the contract is not priced as a 'loss leader'. Alternative names for the net premium are: *mathematical premium*, *pure premium* and *risk premium*.

Exercise 5.7

What is a 'loss leader'?

The net premium valuation method is relatively insensitive to changes in assumptions, as a change in assumptions forces a recalculation of the net premium.

For example, consider a simple term assurance contract. Suppose the valuation mortality rate is increased. This new assumption will increase the likelihood of payout. It will have the opposite effect on how many premiums are expected. The result is an increase in the gross premium liability. The net premium liability is affected less as the increase in benefits will cause an increase in the net premium.

Expenses are not valued as part of the method. There is an implicit assumption that the difference between the actual premium and the net premium will be sufficient to cover expenses. In jurisdictions where the net premium liability is used for prudential purposes, it is common for the prudential regulator to require a check that expenses are indeed covered by the gap between actual and net premiums.

The net premium liability may be modelled using a formula or cash flow approach.

Exercise 5.8

Use the following assumptions to create both a net premium and gross premium liability for a ten-year term assurance. Interest and mortality is expected to follow a Normal distribution. Investigate the sensitivity of the valuation methods and state the confidence interval for your results in each sensitivity test.

You may use the mortality table in the attached spreadsheet to create the necessary commutation columns.

All contracts sold to non-smoking males on their 30th birthday.

Interest: N(0.04, 0.1)

Mortality: N(80% of AM92, 0.03)

Initial Commission: 90% of the first year's premium

Renewal commission: 5% of each subsequent premium

Initial expenses: $200

Renewal expenses: $50 per annum incurred at the start of each policy year, excluding the first year.

Expense inflation is 2.5% per annum

Claim expenses: $300.

Historically, the net premium method was used with conservative assumptions, to achieve implicit margins for prudential capital adequacy. It was developed during the 19th century in the UK, where bond yields were stable (albeit with gradual falls and corresponding rises in shares), tax was virtually non-existent and life companies could tightly control their expenses. Commission was payable at the same rate on each premium rather than a high initial commission with a subsequent lower renewal rate. There was a belief in the concept of a 'true' mortality table and a 'true' rate of interest. At that time, the concept of select mortality was not understood.

The net premium method has caused significant debate within actuarial circles, especially as many of the reasons for its development were not applicable shortly after its proposal in the 1850s. The method is certainly in decline but is still used in many countries. Another reason for its inclusion in this subject is that it introduces the concept of changing models to meet changing circumstances.

Example: Participating policy net premium valuation

The contract in this example is the same as the contract in the gross premium liability section. The contract is an annual premium whole-of-life assurance policy issued by a mutual life company to a life aged x exactly at issue. The initial sum insured of $B plus any attaching reversionary bonuses are paid at the end of the policy year when death occurs. Assume the life company declares a compound bonus of *b* each year and the policy year coincides with the date that annual reversionary bonuses are declared.

The net premium liability at time *t* is:

$$ {}_tV_x = CA_{x+t} - NP\,\ddot{a}_{x+t}, $$

where the net premium $NP = \frac{B\,A_x}{\ddot{a}_x}$, *B* is the original sum assured, and *C* is the sum of *B* and declared bonuses. Interest and mortality are defined by the valuation basis.

We can make the following observations from the formula above:

- the liability at the start of the contract is zero and this is true for any contract valued using the net premium method;
- there is no allowance for expenses;

- unlike the gross premium liability, there is no allowance for future bonuses;
  - only contractually guaranteed bonuses are included in the liability;
  - this aligns with the contractual promise made to policy owners;
- the net premium only includes the original sum insured and does not change throughout the contract term;
  - this produces a higher liability as declared bonuses are counted as a positive, but loadings in the premium to pay for these bonuses are not considered;
- assets (the reserve) equal to the liability at the start of a policy year plus the premium due at the start of the year, inflated by expected investment returns, will be sufficient to meet the liability at the end of the year before bonus is declared plus pay expected claims at the end of the year;
  - in symbols:

$$({}_tV_x + NP)(1+i) = C\, q_{x+t} + {}_{t+1}V_x\, p_{x+t}$$

  - the new liability will be increased when the bonus is declared
- the difference between the office premium and the net premium emerges each year as a surplus item that can be used to pay for expenses and declared bonus
  - assuming no change in valuation assumption, and that experience matches the assumptions, this implies that the surplus emerging will be constant as it is the difference between two unchanging items;
  - a constant surplus emerging would suggest that reversionary bonus rates need to decrease each year, as the rate usually applies to the sum assured and the sum of past declared bonuses;
  - thus, best estimate assumptions do not produce surplus in line with a constant reversionary bonus.

The final bullet point shows that an alteration to the assumptions is required so that surplus emerges in line with a uniform reversionary bonus. A simple solution is to set a conservative (i.e. low) valuation interest rate. A first approximation to the conservative rate is simply the expected return less the desired bonus rate. There are formulae for the exact relationship but this takes us beyond the syllabus. The assets backing the policy liability will increase each year by actual investment returns, assumed to be *i*. By assumption, the valuation basis expects the liability to earn a conservative rate, *i-b*. Thus, there will be approximately a surplus of *b* times the valuation reserve. This surplus, together with the margins in the office premium, pay for the increasing amount of reversionary bonus. The concept of analysing surplus is discussed in Module 12 (Analysis of surplus).

A simple algebraic example may help to understand the points in the previous paragraph. Suppose the reserve at the start of the period is V_0, actual premiums payable at the start of the period are P with corresponding net premiums of NP, and claims payable at the end of the period are C . The expected increase in reserve over the year is $(V_0 + NP)(1 + i - b) - C$. The expected increase in assets over the period, assuming expenses are E, is $(V_0 + P)(1 + i) - C - E$. Thus, the expected surplus is $bV_0 + (P - NP)(1 + i) + b\,NP\, - E$, which is a surplus of approximately b times the valuation reserve plus bonus margins in the actual premium.

The net premium method can be used for traditional contracts such as immediate annuities, endowment assurance, pure endowment and term assurance. The method is applicable to both non-participating (non-profit) and participating (with-profit). It cannot be applied where the contract terms are too complex or applied to stepped premium risk business because the net premium method assumes that premiums are level. It does not work with unit-linked business.

Exercise 5.9

You may want to revise the Life Contingencies subject and demonstrate that

$$({}_tV_x + NP)(1 + i) = C\, q_{x+t} + {}_{t+1}V_x\, p_{x+t}$$

There will not be any questions on the examination that require you to manipulate commutation functions, but you will be expected to demonstrate numerical competency in the ideas from the Life Contingencies subject. There are spreadsheet examples later in this module that develop the core ideas and it is anticipated that these will need to be mastered to reach pass standard.

Acquisition costs

When the net premium method was introduced, expenses were level and more controllable than today. The method is not designed to cope with non-level expenses. In particular, it does not deal well with high initial acquisition costs.

As mentioned in the gross premium liability section, the office premium payable contains an allowance of $\frac{IE}{\ddot{a}_x}$ to pay for the initial expense (IE) and, hence, initial expenses are 'recovered' over the life of the contract. This leads to a new business strain of $IE(1-\frac{1}{\ddot{a}_x})$, which must be funded from capital. It is refunded over the policy lifetime as $\frac{IE}{\ddot{a}_x}$ falls into surplus each policy year. The rate of new business sales can affect IE through the spreading of fixed costs. The implications on the rate of new business sales are discussed in the LI&R Product Development subject.

Variations on the net premium method were therefore devised to recognise the effect of the new business strain and produce a more meaningful profit or surplus release over time. Variations that were developed are now highlighted.

Zillmer adjustment

The Zillmer adjustment adds the loading of $\frac{IE}{\ddot{a}}$ to the net premium. The Zillmerised liability for the example above is:

$$ {}_tV_x = CA_{x+t} - (NP + \frac{IE}{\ddot{a}_x}) \ddot{a}_{x+t} $$

The adjustment weakens the valuation liability although the original liability is arguably far too high. The initial value of the liability is now -IE and a negative value may persist for a number of years, especially at young ages with few expected deaths in the early contract years.

The IE factor can be adjusted downwards to limit the extent of negative liabilities arising at earlier durations.

Preliminary term method

Sprague (1870) suggested to allocate the first (annual) premium, for a whole of life contract, to pay for the initial expenses and claims arising in the first policy year. The consequence is the (higher) net premium is calculated for a person one year older at entry. The corresponding valuation liability for a whole of life participating policy is:

$$ {}_tV_x = CA_{x+t} - (A_{x+1} / \ddot{a}_{x+1}) B \ddot{a}_{x+t} $$

The method may be extended by adjusting for a different period for different types of contracts. The extended version is sometimes called the *modified preliminary term* method. However, the adjustment is only a rough approximation of the actual acquisition expenses. Initial commission can vary significantly between whole of life policies and endowments of different terms. Other acquisition costs can also vary from policy to policy as a proportion of premium.

As with the Zillmer adjustment, the Sprague method would produce negative liability values at early policy durations (this is due to the modelled premium being higher than the theoretical pure net premium). Negative liability values may not be appropriate for a prudential capital adequacy valuation and are often set to a minimum of zero.

Exercise 5.10

Why are negative liabilities not appropriate for prudential capital adequacy valuations?

Renewal expense adjustments

Another modification that has been used is to specify that the net premium shall not exceed k% (<1) of the office premium. This modification is aimed at making at least a minimum allowance for renewal expenses.

Effect on the balance sheet

Net premium bases were historically used for prudential capital adequacy as well as general purpose reporting, so negative liabilities were not considered appropriate (negative liability values effectively treat expected future positive cash flows as an asset to offset against current liabilities). If reserves are grouped for an entire portfolio of similar policies, the negative liabilities for those at lower durations may be offset by positive liabilities for those at higher durations, so results overall may be acceptable. However, the strength of the valuation basis will depend on the mix of durations in the portfolio.

Exercise 5.11

Suppose life company A is a relatively young proprietary company and premium income is growing rapidly. Suppose company B is a well-established mutual organisation that has some premium growth. Consider the effect of introducing a Zillmer adjustment on the liabilities. Project forward the balance sheet for a few years, assuming growth continues.

5.2.4. Accumulation (retrospective) method

In previous sections, prospective methodologies were covered, where liability values for future claims are based on present values of expected future cash flows. Under various (unrealistic!) conditions, the opening section of this module showed that for a contract in force, the gross premium prospective approach was identical to the past accumulation of premiums paid less an allowance for expenses and the cost of assurance.

Exercise 5.12

1. Briefly justify two conditions that are required for the equivalence between the retrospective and gross premium reserves of a non-profit endowment assurance at the start of the n^{th} policy year.
2. How would you change your answer if the contract was replaced by a participating contract?
3. Explain why equality is unlikely.

The example presented in Table 5.1 is a simple numerical example based on a level premium term contract with a sum insured of $100,000. The example demonstrates that policy liability values are identical under accumulation (retrospective) and projection (prospective) approaches, when using the criteria from Exercise 5.8. In the example, for simplicity, there are no expenses and no investment earnings or discounting.

A reminder from Module 1 (Introduction): In this and all subsequent modules, the table number also refers to the worksheet associated with the module. For example, the numbers in Table 5.1 below can be found in the spreadsheet “LI&RV_Module5” in worksheet “Table5.1”.

Table 5.1: Equivalence of methods

Year	Premiums	Claims	Expenses	Net cash flow	Past cash flow	Future cash flow
1	781	-620	0	161	161	-161
2	659	-591	0	68	229	-229
3	589	-598	0	-9	220	-220
4	526	-605	0	-78	142	-142
5	469	-611	0	-142	0	0

The policy liability at the end of each year can be calculated either as the accumulation of past premiums less claims or as the projected future claims less premiums. For example, the liability at the end of Year 2 can be calculated as:

- retrospective approach: 781 − 620 + 659 − 591 = 229 in the past cash flow column
- prospective approach: 9 + 78 + 142 = 229 i.e. the negative of the future cash flow column

Algebraic examples of retrospective and prospective reserves were developed in the Life Contingencies subject. There is a lot of algebraic manipulation required to demonstrate equivalence, either in general or for particular contracts, although that will not be re-examined. You are likely to be tested through using spreadsheet calculations.

There is no unique method when determining a retrospective liability. The model may be a formula or cash flow approach. The basis may be either actual experience, a mixture of actual experience and assumptions (e.g. use expected mortality and actual investment returns), or a notional basis (e.g. the current valuation basis or the original premium basis). Some potential examples are listed below:

- a net premium retrospective reserve, as the name suggests, uses the net premium and ignores expenses and profit;
- a gross premium retrospective reserve using the original premium basis will equate with the prospective gross premium liability if the valuation basis is the same as the original premium basis;
  - this may provide a shortcut when valuing contracts that have complicated future benefit levels as the calculation of the retrospective reserve is easier but one has to check the realism of the answer;

- a gross premium retrospective reserve using actual experience for a cohort of policies; and
- a gross premium retrospective reserve for participating business using actual experience for the entire class of participating business and making deductions to pay for notional guarantee costs;
  - participating contracts offer a minimum level of returns even where invested partially in risky assets;
  - the cost of the guarantee may be borne by shareholders, shared between shareholders and participating business policy owners, or totally by the latter group in a mutual.

Contracts valued using the accumulation method

An equation of value would suggest that all contract types may be valued using an accumulation approach. This doesn't happen in practice because there are difficulties in determining an appropriate retrospective liability and determining the prudence of the resulting reserve. For example, a model may need historical data going back as far as the commencement date of the oldest policies still in force. Obtaining this data can be a challenging exercise if accurate retrospective liabilities have not previously been calculated.

Prudential regulators may allow life companies to use a retrospective approach but often add a test to ensure the resulting liability is not lower than that determined by a prospective method. It is more common for the method to be used in conjunction with a prospective method.

Contract types that use this method are:

- group risk business is typically short term and has relatively level expenses:
  - the risk is typically level; i.e., the benefit outgo is broadly matched by premium income each year;
  - part of the premium received relates to risk occurring after the valuation date and this creates a liability called the *unexpired premium reserve*;
  - the balance of the premium collected pays for costs and past claims;

  - there are claims that have occurred but are either unknown or not accepted by the life company; these are discussed in Section 5.3;
  - allowance is made for expenses incurred but a test is usually necessary to determine if initial expenses are recoverable;

- unit-linked and investment-linked business use a mix of accumulation and prospective methods:

  - balances payable to policy owners or members are known and backed by an offsetting asset;
  - a non-unit reserve, calculated prospectively, may be required to ensure that future expenses can be met by the combination of future fees and the non-unit reserve;
  - in some jurisdictions, negative non-unit reserves may be partially or fully offset against other liabilities;
  - there may be rider benefits that require prospective methods;

- participating business relies on the concept of retrospective reserves, also called *asset shares*, as follows:

  - the value of accumulated assets is, in some sense, the amount that is returned to participating policy owners and shareholders, for proprietary companies, in defined proportions;
  - determining supportable bonuses for participating business (the bonus earning power) involves comparing asset shares with prospective valuations until a particular bonus rate is found that equates the two calculations;
  - comparing the aggregate asset value for a particular cohort with a projection method may help determine terminal bonus scales;
  - a related idea is comparing asset shares with notional funds in unitised with-profit business.

5.2.5. Deterministic versus stochastic

A deterministic valuation is a projection of a single scenario with a single estimate for each assumption; usually an estimation of the mean of the underlying probability distribution of the variable. A deterministic valuation is a single view of the future.

Liabilities are uncertain and deterministic valuations provide no information on the range of possible outcomes. While deterministic valuations may be re-run using varied assumptions to provide an indication of the financial impact of adverse or favourable deviations, the results provide no information on the probability distributions associated with particular outcomes or result ranges.

For these reasons, deterministic valuations are not suitable for certain types of liabilities. An example is a guarantee that the policy crediting rates will not fall below a certain minimum, say 2.5% pa. A deterministic valuation using an investment earning rate of 3% pa would attribute no cost to this guarantee. This is referred to as an *asymmetric risk*. The likelihood of returns below 2.5% is low and outcomes where a cost would be incurred represent the tail of a probability distribution of future outcomes. While the likelihood of this outcome is low, there is still some cost attached to this guarantee which must be allowed for in the liability valuation.

A stochastic projection, also referred to as a *simulation analysis*, could be used to capture the cost of such a guarantee. In a stochastic projection, the inputs used to drive cash flow projections are random variables. Probability distributions are assigned to projection inputs such as future investment earnings rates. Inputs for each single projection are randomly generated, based on the underlying distributions, with large numbers of projections (or scenarios) being generated. Under this approach, instead of the liability being generated as a single scenario, it is based on an average of the results of all the scenarios generated. Many thousands of scenarios may be required to provide stable, meaningful results. Stochastic valuations are increasingly used for prudential capital adequacy calculations, where results for more extreme outcomes are critical.

In the example above, a small proportion of (adverse) scenarios would have resulted in a cost emerging from the 2.5% minimum rate guarantee. These scenarios would be included in the overall average. Their impact on the calculated value of liabilities would reflect both the quantum of the financial impact and the probability of the scenario occurring.

Other examples of asymmetric risks arising from life insurance contracts that may be valued using stochastic methods include:

- **Guaranteed minimum surrender and maturity values** in participating business and discretionary non-participating business: Bonus or investment earnings can be credited to policies but cannot be subsequently reduced or removed if investment losses occur. If a mean investment return is assumed, the possibility of negative investment returns at some point in the future would be ignored.
- **Profit sharing for group risk business**: Under many group risk contracts, underwriting profits are shared with the policy owner by providing rebates when experience is good. However, when experience is bad, losses are not usually shared. Further, any provisions for future removal or reduction of rebates, once credited, are usually very restrictive.

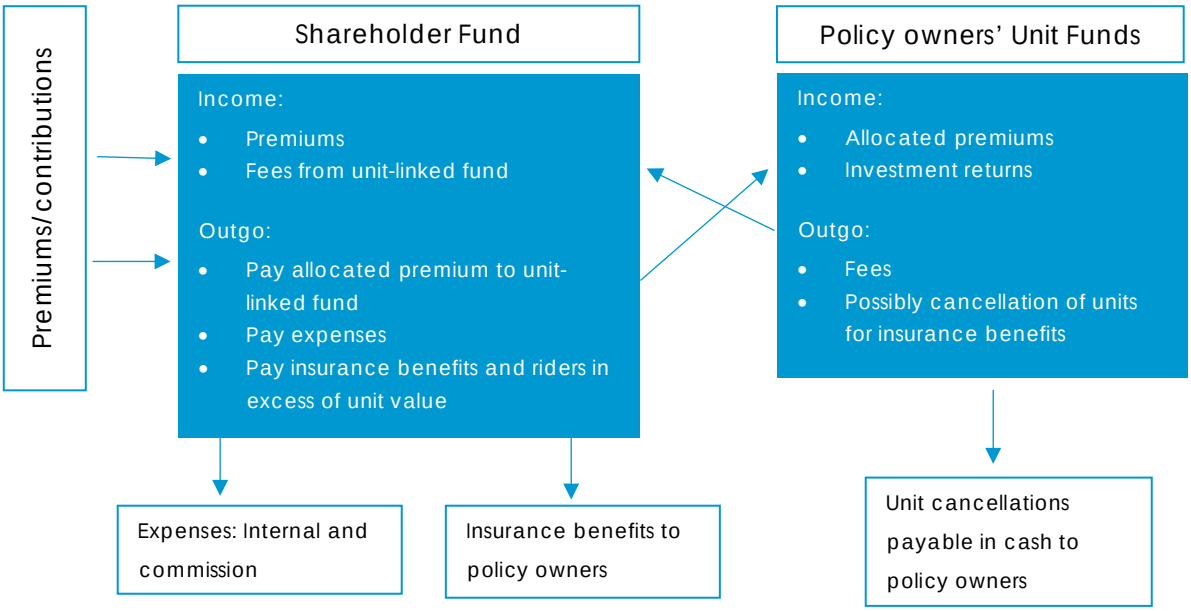
Results under a stochastic modelling approach are critically dependent on the underlying distributions used for the modelled parameters or inputs. Selection of probability distributions requires judgement and often involves considerable statistical analysis. Different underlying distributions can result in very different results. Also, while some parameters may act independently of others, some may have important correlations that need to be captured in the model. For example, there are strong correlations between interest rates, inflation rates and equity share prices.

Stochastic valuations require significant computer power. Thousands of projections may be generated for individual policies over multiple years. Even in the current era, where substantial computing power is readily available, methods are often employed to make stochastic projections more manageable. Grouping data or using a narrower range of representative policy profiles to model portfolios are some of the techniques employed.

5.2.6. Unit linked policies

This section will discuss the valuation of unit-linked liabilities. Unlike conventional business, it is relatively easy to separate policy owners' interests from shareholders' interests.

Figure 5.2



There are many variations of unit-linked contracts, and policy owners often have the freedom to choose benefits that transform the contract from a savings vehicle to an almost pure risk product. These variations are not directly related to the concepts within this unit but a key point is that the policy owner or defined contribution fund member is aware of:

- the premiums that they have contracted to pay;
  - policy owners may have specified a nominal amount, or possibly with a fixed annual increase;
  - defined contribution (DC) members may pay a percentage of their gross salary although may not know the impact of taxation.

- The allocation rate to the unit-linked funds;
  - this is likely to be 100% for DC funds;
  - a variety of methods may apply for life companies, ranging from level allocations (e.g. 95% of each premium is allocated to unit funds) to zero in years one or two, and 100% thereafter.
  - Irrespective of the method, the policy owner 'knows' what percentage of their premium is allocated to the unit fund although this may not be the whole story as the life company may have a wide spread between the purchase and sale price of units.
- The explicit management fees that will be deducted from the returns on the underlying assets;
- some policies allow a choice of insurance benefits, which are usually costed by deducting units; and
- they, and regulators, expect companies to invest in accordance with the published investment mandate (for example, a small company equity fund should invest in small companies, as defined in the promotional material).

The company (shareholder fund) receives the premium and allocates the appropriate part of the premium to the chosen unit-linked funds. The policy owner is taking all the investment risk although the life company is providing a service; the pooling of investments and management of systems, recording of prices and so on. The life company will also receive any charges in relation to insurance benefits.

Similar remarks apply for DC funds, whether they are mutual or proprietary, although the processes may be more complicated. For example, insurance benefits will 'pass through' to an insurance company.

This subject does not cover the technical difficulties in determining unit prices and the management of unit-linked administration systems. These ideas are developed in the LI&R Product Development and Application subjects. This subject will assume there is an appropriate unit price that is relevant to the purpose of the valuation.

Valuing unit-linked policies

Unit linked policies essentially provide a benefit of the value of the unit balance on exit at any time, less any defined surrender penalties. The unit balance is the sum of the number of units held in each unit fund held times each fund's unit price. It represents the accumulated asset share allowing for all past information. The value of the unit balances is sometimes referred to as the *unit reserve*. This is consistent with the terminology in this subject, where we have referred to reserves of assets backing liabilities.

If future fees and expenses were matched, then the valuation of unit-linked policy liabilities can involve little more than calculating unit balances. Companies generally seek to match the timing of fees and expenses in setting pricing terms for unit-linked business and, therefore, unit balances are widely used for the valuation of unit-linked business. However, the process of matching fees and expenses may involve complications; these are considered in the LI&R Product Development subject.

Similarly, account balances are often used to value investment account policies. Investment account policies can work in a similar way to unit-linked policies except that benefits are based on an account balance, being the accumulation of premiums and credited interest less fees.

In practice, there are a number of issues that can impact the valuation of unit-linked liabilities, which need to be considered.

Investment guarantees

A life insurance company may offer investment guarantees that expose the company to investment risk.

Examples of guarantees are minimum crediting rates (e.g. 3%) on investment account policies or a guarantee that unit prices will never fall. Often, the risks of investment guarantees are largely offset through selection of appropriate investment strategies. For example, guarantees that returns will never be negative are often offered on units for short-term fixed-interest or near-cash securities. The LI&R Product Development subject will discuss whether policy owners understand the implicit cost of lower expected returns.

Nonetheless, companies do offer investment guarantees on risky assets. In valuing liabilities, the actuary would need to consider the risks of investment guarantees, the cost of offsetting those risks and the impact of any residual risks. Often, stochastic modelling techniques are required to assess strategies and value residual risks. Assessment of investment guarantees, hedging and dynamic investment strategies are specialist areas and beyond the scope of this subject. For this subject, it is important that the actuary is aware of guarantees and their management and ensures that steps are taken to reflect these appropriately in valuing liabilities.

It is also important that the actuary understands the cost of investment management strategies if those costs are to be met by the company. Often such costs, however, are deducted as fees to the policy holder as the costs are incurred. Therefore, the cost of investment management does not generally require further consideration for a unit-linked valuation of liabilities.

Insurance coverage

Unit-linked policies may have optional term insurance cover, referred to as *rider cover* or *benefits*. Under rider cover, premiums are charged through the cancellation of units. The insurer pays the contracted sum insured if the life insured dies or suffers an insured event, such as total and permanent disability, within the contract term.

Rider cover is generally valued separately in a similar way to term insurance policies sold on a stand-alone basis. Rider cover can provide sums insured that decrease as the value of units or policy owner account balances grow. This allows the total amount payable on death (ie sum insured plus unit balances) to be constant, irrespective of the unit balance. Other policies do not adjust the sum insured for the unit balance, and pay a contracted sum insured plus the unit balance on death. Valuation models would need to reflect the exact features of the contract.

Altering future charges

Some contracts allow companies to modify the fees charged to policy owners. It may be appropriate in some circumstances for the actuary to assume that the company will increase its fees (or premium rates) in the future. For example, if administration costs had risen significantly more than anticipated when policy terms were set, a possible management action may be to increase fees, subject to contractual terms and conditions. The company would also consider policy owner expectations, which may be influenced by past company and industry practice. A realistic internal valuation may show the effects of the management actions although the prudential reserves may not anticipate the future changed charging structure.

Non-unit reserves

If future fees under unit-linked policy series are likely not to cover future expenses, then a non-unit reserve is required. This may occur on day 1 if the contract is not profitable.

Even for profitable business, there may be a temporary period where expected fees are insufficient to cover expenses, despite adequate expected profitability in the longer term. For policies paying monthly or annual premiums, lower balances may lead to lower fees initially. There would be a new business strain and capital may be required to support the contract. Fees would be expected to increase as account balances grew, thereby reversing this situation.

A general principle is that the company should have sufficient capital at the outset of the contract so that recourse to capital during the currency of the contract is not required.

Exercise 5.13

Suppose a unit-linked contract offered an allocation to units at 100% for all years, except year 15, where the allocation was 120%.

Calculate the non-unit reserve. You may make simplifying assumptions but they need to be justified.

Write down a general approach for calculating non-unit reserves

Deferred acquisition costs

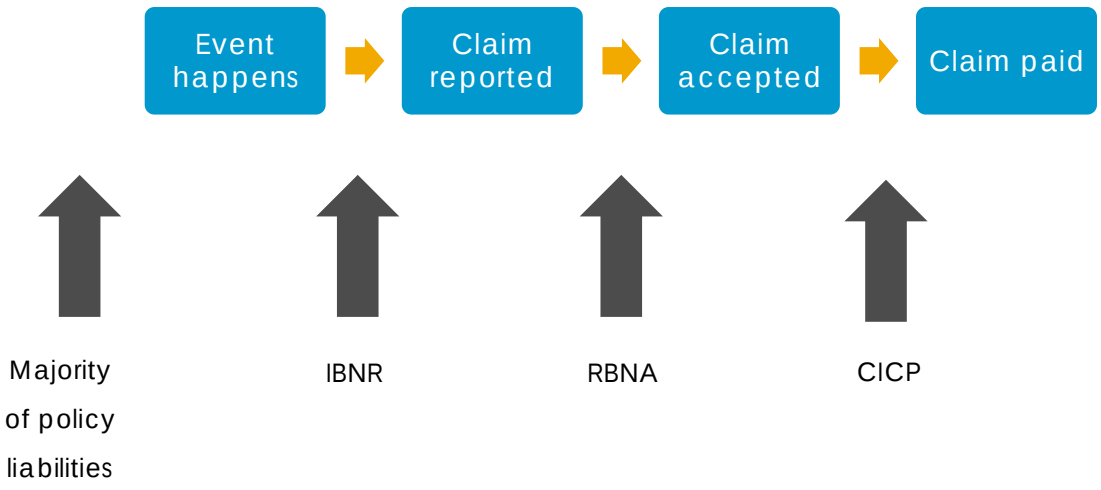
Adjustments to liability values may be used to allow for the deferral of acquisition costs for reporting purposes. This is covered in Module 6 (Profit).

5.3. Provisions for claims incurred

The valuation methodologies discussed in previous sections of this module have included allowance for benefits to be paid on future events leading to claims, such as the death of a life insured.

Policy liabilities also needs to include an allowance for events that have already occurred but are not yet fully settled at the valuation date. These liabilities arise due to delays that occur between an event happening (e.g. the policy owner becomes disabled), their claim being reported to the life company, and that claim being accepted and paid, as depicted in Figure 5.3.

Figure 5.3



Liabilities caused by such delays can be grouped into the following three categories:

- **IBNR (incurred but not reported)**: Claims that have occurred and are payable but have not yet been reported to the company. For example, a life insured may have died, but that death may not yet have been reported to the life insurer.
- **RBNA (reported but not admitted):** Claims that have been notified to the company but have not yet been settled. For example, trauma claims can be complex to assess due to the various (and complex) definitions of trauma outlined under policy contracts. These claims may be in the process of being assessed for acceptance or rejection at the time of the valuation. These are also referred to as *pending claims*.
- **CICP (claims in the course of payment):** Claims that have been approved but are settled over time such as income protection (disability income) claims. They are also referred to as Disabled Lives Reserves (DLR), referring to the actuarially-based value of reserving for the claims.

  Methodologies used to value liabilities relating to IBNR and RBNA are discussed in the following two sections. The valuation of CICP claims is covered in the example on the valuation of Disability Income policies in Section 5.4.5.

5.3.1. IBNR Claims

IBNR claims may not yet be reported to the company for a variety of reasons. For death claims, the beneficiaries may not be immediately aware of the life policy. For disability income and TPD claims, the "waiting period" before qualifying for a claim may cause notification delays. For TPD claims, delays of several years between the incidence and reporting of claims are common. For group insurance provided to retirement funds, considerable delays in the claim being reported are caused both by delays in notification by members or employers and delays caused by a fund's administrative and other processes.

These types of reporting delays are predictable for certain types of business. Statistical estimation techniques based on past claim notification delays are likely to be applied. These techniques are especially likely to be used for group risk policies within retirement funds where IBNR claims are likely to comprise a large part of the liability.

Common methods for calculating IBNR liabilities include:

- average delay between date of incidence and date reported; and
- chain ladder methods.

The first method is simple and should give reasonable results if delays between incidence and reporting are relatively short. If the average delay is three months, the IBNR liability would typically be set to equal the cost of claims reported for the three months prior to the reporting date.

A chain ladder method is a more appropriate method of estimating IBNR liabilities if reporting delays are longer than a few months. This method utilises the pattern of reporting delays from past claims while still taking into account actual claims experience to date for each incidence year (the year in which the claim actually occurred). The chain ladder method analyses the delays between incidence and reporting for claims in the past. It projects future reporting of claims by starting with the claims that have been reported to-date and assumes that the pattern of future claim development will be similar to the past pattern. IBNR claims are estimated under the chain ladder method by averaging claims development or run-off factors based on past claims reported.

Each claim that has been admitted in the past must be categorised by both year of incidence and year of reporting. This is presented as a 'claims triangle', with reporting years in columns and years of incidence in rows. The diagonal of the triangle represents claims reported in the last 12 months. The claim development patterns in the triangle are used to estimate the claims that have been incurred in the past but have not yet been reported. An example of the application of a basic chain ladder method is presented below.

The steps under the basic chain ladder method are as follows:

Figure 5.4: Steps under basic chain ladder method

These techniques were introduced in the Foundation subject. There are many variations of the chain ladder method but these are beyond the scope of this subject. The interested reader may consult *Actuarial Practice of General Insurance* (Hart, Buchanan and Howe).

IBNR chain ladder example

Tables 5.2 a, b, c and d summarise an IBNR liability calculation as at 31 December 2017 for TPD claims. Students need to be able to apply and adapt this method.

In Table 5.2a, the non-shaded amounts are historical. The shaded amounts are projected. The non-shaded amounts are the cumulative claims costs by duration since the claim occurred. The duration since the claim occurred can also be referred to as the *reporting delay*. Also, the year in which a claim is reported is sometimes referred to as the *development year*, while the year that a claim occurred is referred to as the *incidence year*. For a claim that occurred in June 2011 and was reported in June 2013, the incidence year is 2011, the development year is 2013 and the reporting delay is two years. The data covers claims reported up to 31 December 2017 that were incurred between 2010 and 2017. The data is split by incidence year in rows and durations are grouped in columns (0, 12, 24 months, etc. from the end of the incidence year). Also shown are earned premiums for each year, which are used later to calculate loss ratios.

For example, for claims incurred in 2011, the total cost of claims reported up to the end of 2017 was $44,373. Of the claims incurred in 2011, the cost of claims reported with delays of between 12 and 24 months is $7,344 ($16,995 - $9,651).

Note that relatively few claims are reported during the year of incidence, hence the need for special consideration of calculations for the latest incidence year. The method used to calculate results for 2017, shown in Table 5.2a, is explained towards the end of this section.

The shaded areas are estimated claims costs, based on claims development factors using the historical (unshaded) data. The development factors are shown in Table 5.2b. The development factor for future claims costs where the claims are reported with a delay of 36–48 months is 1.25. The projected cumulative claims costs for claims incurred in 2014 and reported with a delay of up to 48 months is $60,856 ($48,804 × 1.25) The projected cumulative claims costs for claims incurred in 2015 and reported with a delay of up to 48 months is $56,075 ($44,970 × 1.25).

Table 5.2a Cumulative reported claims

Incidence year	Earned premiums	Cumulative reported claims by duration since claim occurred ($'000) (including IBNR estimates)							
		0	12	24	36	48	60	72	84
2010	60,125	3,331	12,811	20,370	26,656	37,667	44,414	48,701	48,701
2011	65,235	1,448	9,651	16,995	30,354	40,594	44,231	44,373	44,373
2012	75,282	1,530	16,995	40,180	58,866	71,707	71,707	75,283	75,283
2013	78,970	5,161	28,674	47,432	70,340	71,690	78,111	82,007	82,007
2014	80,155	6,225	27,066	46,783	48,804	60,856	66,307	69,613	69,613
2015	76,949	4,325	19,477	31,732	44,970	56,075	61,097	64,144	64,144
2016	75,410	932	18,632	33,311	47,208	58,865	64,138	67,336	67,336
2017	77,295	2,232	18,854	33,708	47,770	59,566	64,902	68,138	68,138

Table 5.2b shows claims development factors. These factors are the ratios of cumulative claims reported over successive claim development years (shown in Table 5.2a). For example, the claims development factor for 2011 for the period from month 12 to month 24 is 1.76 ($16,995 / $9,651). This means that, for the 2011 incidence year, the cumulative claims cost for claims reported with a delay of up to 24 months is equal to 176% of the cumulative cost for claims reported with a delay of up to 12 months.

The development factors used to calculate projected claims costs are the average (unweighted) of the factors calculated for each incidence year. The factor for the period from month 72 to month 84 only has one observation, being that for incidence year 2010. The factor is 1, meaning that it is expected that, according to the development factors derived below, all claims are expected to be reported by the end of month 84.

Table 5.2b: Claim development factors

Incidence year	Earned premiums	Claim development factors							
		0	12	24	36	48	60	72	84
2010	60,125		3.85	1.59	1.31	1.41	1.18	1.10	1.00
2011	65,235		6.67	1.76	1.79	1.34	1.09	1.00	
2012	75,282		11.11	2.36	1.47	1.22	1.00		
2013	78,970		5.56	1.65	1.48	1.02			
2014	80,155		4.35	1.73	1.04				
2015	76,949		4.50	1.63					
2016	75,410		19.99						
2017	77,295								
average				1.79	1.42	1.25	1.09	1.05	1.00

Note that Table 5.2b does not contain an average development factor for the period from month 1 to month 12 as the relatively small number of claims reported during the year of incidence makes this ratio quite volatile. An alternative approach is used for the 2017 incidence year, as presented later in this section.

Table 5.2c shows the final calculation. The value of the IBNR liability is $1,657,136. This is calculated by determining the expected cost of outstanding claims for each future calendar year and applying a 5% discount rate (assuming claims are paid, on average, halfway through the year).

For example, the cost of claims expected to be reported (and paid) in 2018 is $64,983. This is obtained by summing amounts from Table 5.2a: 2232 + (33,311 − 18,632) + (44,970 − 31,732) +... etc. and then discounting for half a year at 5%.

The example modelled assumes no delays between the reporting of claims and their final settlement. The model would need to be adapted, if necessary, to reflect any further delays.

Table 5.2c: IBNR claim payments

	IBNR claim payments by payment year								
	2018	2019	2020	2021	2022	2023	2024	Total	Total IBNR Liability
Face value	66,588	49,202	34,049	20,116	8,534	3,236	0	181,724	
Present value (5% disc.)	64,983	45,729	30,139	16,958	6,852	2,475	0	167,136	**167,136**

Modified approach for claims incurred in 2017

As discussed earlier, a modified approach is used for incidence year 2017 due to the small amount of available data. The projected claims cost is based on an average of observed loss ratios (claims costs as a proportion of earned premiums) for all other years combined, applied to the premium income for 2017. If premium rates had changed at some point, the earned premiums would need to be adjusted so that the loss ratios were measured on a consistent basis.

Table 5.2d shows the loss ratio calculation, with an overall loss ratio of 88%. The total projected cost of claims for 2017 is \$68,138 (0.88 × \$77,295). Of this, \$2,232 has been reported to date. The cumulative cost for each duration is obtained by dividing by the successive claims development factors. For instance, the cumulative claims reported up to duration 60 is \$64,902 = \$68,138/1.049867 (shown rounded to 1.05 in Table 5.2b).

Table 5.2d Loss ratio calculation

Incidence year	Total expected claims costs	Earned premiums	Loss ratio
2010	48,701	60,125	81%
2011	44,373	65,235	68%
2012	75,283	75,282	100%
2013	82,007	78,970	104%
2014	69,613	80,155	87%
2015	64,144	76,949	83%
2016	67,336	75,410	89%
2017	68,138	77,295	
	Average loss ratio based on 2010 to 2016		88.15%

Exercise 5.14

If the loss ratio implicit in pricing business for 2017 was materially different from the historical average, how would that affect the ratio to be used for modelling IBNR?

Why might the two be different?

Exercise 5.15

How reliable would the basic chain ladder method be, as applied in the example, under the following conditions and how might the approach be adapted?

- Exposure (premiums written) had increased significantly over the investigation time period due to a few very large new funds
- Reporting requirements or conditions under policies changed significantly over the period
- Loss ratios show a strong increasing trend over time

It is important to understand that any statistical method of estimation will have strengths and shortcomings. The chain ladder method is an example of a lag method. The Society of Actuaries commissioned a study on the accuracy of commonly used IBNR estimation methods in health insurance over a range of scenarios. The study found that lag methods tend to be the most commonly used. However, lag methods consistently showed the highest standard deviations when compared with the other methods in the study. They also require significant amounts of claims completion before reliable estimates can be developed. It is outside the scope of this subject to cover other methods for estimating IBNR liabilities.

5.3.2. RBNA claims

RBNA claims arise, for example, when a trauma or TPD claim has been reported to the insurer and there is outstanding medical or other evidence required before a decision about the claim can be made. They also arise when a rejected claim is under dispute.

While reserves for RBNA claims could be based on policy sums insured, this may overstate the value of the liability as some claims will be rejected. Estimates of RBNA claims costs will impact profit for the period and the cost of reserving. Miscalculating RBNA claims costs can, therefore, have a material impact on results for a period, even if the ultimate cost is not affected.

Reserves for RBNA claims may be based on expert assessment of each individual claim (case assessments), which are often made by claims managers. Alternatively, the probability of claim acceptance can be determined statistically in assessing liabilities for these claims.

5.4. Valuation modelling examples

5.4.1. Illustrative examples

The examples in this and subsequent sections illustrate the concepts and techniques introduced above. The products presented are level premium term, stepped premium term, endowment insurance, and disability income policies.

The examples are based on cash flow projection methods. Valuation approaches currently in use for most product types involve projection of cash flows.

It is important for models used in industry to capture all material product features to ensure accurate results and to facilitate the use of models for other purposes such as business planning. Models developed in the industry generally provide monthly results and incorporate more complexity in modelling and assumptions than is used in these examples. For example, models may include claims rates varying by duration and claim assessment costs. Operational models would also capture many more policy features such as premium payment frequencies, loyalty discounts, and options such as inflation indexation of benefits.

There are no planned margins for profit in these examples. This means that the assumed premiums or fees are sufficient to exactly break even, based on assumed experience. In practice, profit margins are an important aspect of the expected cash flows. The examples presented here will be extended in Module 6 (Profit) to demonstrate techniques for addressing the impact of planned profit margins. All examples are presented on a gross of tax basis. In practice, liability values will also reflect the impact of relevant tax rules. The modelling of tax is discussed in Module 8 (Assumptions).

All examples are supported by Excel spreadsheets. Students should first aim to gain an understanding of the concepts presented. They should then ensure that they can follow the construction of the examples in the spreadsheet. Students will be expected to be able to apply the projection approach by constructing or modifying Excel models. Exam questions are likely to differ from these examples. To deepen understanding, students should also vary the assumptions and other parameters and assess the impacts on results.

5.4.2. Level premium term insurance

Table 5.3a shows projected cash flows, on a realistic basis, for a 10-year level premium non-profit term insurance policy with a $400,000 sum insured. The policy owner agrees to pay an annual premium of $840 at the start of each policy year for ten years. If the policy owner pays the premiums when due, and the life insured (which may not be the policy owner) dies within the contract term, then the life company is contractually obliged to pay the known sum insured of $400,000 to the stated beneficiaries in the contract, unless there are mitigating circumstances.

Exercise 5.16

(i) Provide an example of mitigating circumstances.

(ii) In your opinion, what is a reasonable period between the date of death and payment of a death benefit?

The projections show projected cash flows for a single policy, taking into account the probability of dying or lapsing each year. Notice how the premium decreases each year.

It is common actuarial practice to implicitly use the law of large numbers. The spreadsheet results show the projection of a single policy but it really shows the expected results of a projection of a large number of policies. For a portfolio of 1,000 identical policies, the projection results would be multiplied by 1,000. A single policy either continues or terminates, whereas the proportion of the portfolio that continues or terminates each period represents the conditional probabilities of death or lapse each policy year. The portfolio of policies, or "business", reduces each year through the decrements of death and lapse. The expression "the business runs off over time" is jargon for the on-going reduction in the portfolio.

Cash flows are shown before interest. In this example, premiums are payable annually in advance, expenses are incurred at the start of the year and claims are paid at the end of the policy year.

Since mortality costs increase with age, the risk premium (i.e. the premium calculated ignoring expenses and profit) exceeds the claim costs in earlier years. The excess assets are used in later years when claim costs outgo exceeds risk premium income. The office premium, shown in Table 5.3a, allows for the value of initial expenses and the present value of renewal expenses.

The pricing basis can be summarised as follows:

- mortality: 85% of IA95-97 ultimate rates for a male life, of attained age 45 exact at policy commencement;
- lapse rates: 12% p.a. in years 1 and 2 and 10% p.a. thereafter;
- initial expenses: $70;
- renewal expenses: $70 p.a. from year 2 onwards with an expense inflation rate of 2% p.a.;
- initial commission: 20% of the first year's premium;
- renewal commission: 20% of the second and each subsequent year's premium;
- tax is ignored;
- investment return: 3% p.a. return on assets backing liabilities; and
- discount rate: 3% p.a. used to calculate the present value of future cash flows.

In practice, a risk-free rate is likely to be used as the valuation discount rate. A higher discount rate would be used for pricing, reflecting a higher required return on risk capital supporting insurance products. The setting of valuation assumptions is discussed in Module 8 (Assumptions).

The projection term is 10 years. The projection summarises cash flows each year for a portfolio of identical policies all written at the start of Year 1.

Students should refer to the modelling spreadsheet for further details of the valuation basis and how it is applied in the model.

A point to note is that the examples presented in this module and Module 6 (Profit) have been constructed to illustrate the application of projection techniques and the impact of different liability valuation bases on the emergence of profit. The pricing basis and assumptions are not necessarily indicative of those used in practice. Students are encouraged to talk to pricing and valuation teams within their companies and to refer to life company published reports to gain more insight into the range of realistic assumptions used.

Table 5.3a Net cash flow

Year	Premiums	Claims	Expenses	Net Cash Flow
1	840	-428	-238	174
2	738	-409	-209	120
3	649	-394	-185	70
4	583	-390	-167	27
5	524	-388	-151	-15
6	471	-387	-137	-53
7	423	-387	-124	-88
8	380	-388	-112	-119
9	341	-390	-101	-149
10	307	-391	-91	-176

The value of liabilities at each year end is calculated as the present value of expected future outgo less income; i.e., a gross premium projection liability.

Table 5.3b shows the value of liabilities using three different valuation bases:

- basis (i) is a best estimate or realistic basis: this is the pricing basis shown above although initial costs will have been spent and therefore not affect liabilities;
- basis (ii) (Conservative Basis 1) is a conservative basis where expected mortality rates are increased by 10%; and
- basis (iii) (Conservative Basis 2) is also a conservative basis where expected expenses are increased by 85%.

The company would hold balance sheet reserves equal to the value of policy liabilities, which differ according to the valuation basis chosen.

The examples in this module have been set such that premiums cover expected claims and expenses. The added complexity of profit, and when it should be recognised, is discussed in detail in Module 6 (Profit). Changing the valuation basis will not affect the profit over the life of a contract, subject to various conditions, but it will change when profit is recognised. Table 5.3b includes columns on 'profit' for each valuation basis. It is defined here as the net cash flow less the change in liability over the year.

In the examples below, the assumed discount rate is the same as the assumed interest rate. By setting the interest rate equal to the discount rate, the timing of the release of profit does not affect the eventual discounted value of that profit when released. Where profit is required to be "held back" to support additional reserving, the reserves earn the same rate as the assumed discount rate. In this way, the value of profit is not affected by the timing of release but only by the business experience giving rise to the profit.

It is important to note that the assumed experience used to determine profit under all three valuation bases is the same. The assumed experience is the best estimate or realistic basis. The same cash flows, as shown in Table 5.3a, are used in determining profit under each basis. The difference is that for determining liabilities under Conservative Bases 1 and 2, more conservative assumptions are used. Under Conservative Bases 1 and 2, the value of liabilities and, therefore, required reserves, are higher, as is the interest earned on these reserves.

The spreadsheet model used to produce these tables was run twice for each of Conservative Basis 1 and 2 to determine liabilities and profit. The first time, it was run with conservative assumptions to calculate liability values only. The second time, it was run with the realistic assumption basis.

For Conservative Basis 1, the liabilities are calculated assuming 10% higher mortality rates. This would have a flow-on impact on the policy run-off, with a greater proportion of policies terminating due to death. However, the projected cash flows and business run-off is based on best estimate mortality rates for all results presented in the table, not the conservative mortality rates. For this reason, the modelling of liabilities under Conservative Basis 1 uses a simplification. The liabilities shown under Conservative Basis 1 in Table 5.3b are slightly lower than would be calculated by the actuary at the end of each year. This practical modelling simplification does not invalidate the examples, as the resulting liability values are very close to those that would be obtained if a more accurate model was used. The higher expenses under Conservative Basis 2 have no effect on the policy run-off, so the reserves under Conservative Basis 2 are calculated exactly.

In Table 5.3b, interest is applied to cash flow items according to the assumed timing. For example, premiums are assumed to be received at the start and, thus, earn one full year's interest. The value of liabilities is at the year end and, hence, assets backing the liabilities earn one full year's interest in the following year. Under the best estimate basis, the opening liability value is zero. Under Conservative Basis 1 and 2, the opening liability values are 338 and 354, respectively. These are shown as Year 0 in the table.

Profit is assumed to be earned or released at the end of each year, except that the loss on creation of opening reserves under Conservative Basis 1 and 2 is recognised at policy commencement.

Table 5.3b Liability and profit on different bases

Year	Best Estimate Basis			Conservative Basis 1			Conservative Basis 2		
	Liability	Interest	Profit	Liability	Interest	Profit	Liability	Interest	Profit
0	0	0	0	338	0	-338	354	0	-354
1	192	18	0	497	28	43	495	29	61
2	333	22	0	606	31	41	592	31	54
3	427	24	0	669	32	39	645	32	48
4	479	25	0	689	33	39	659	32	44
5	489	26	0	667	32	39	634	31	41
6	461	25	0	605	30	39	573	29	37
7	397	23	0	506	27	39	478	26	34
8	297	20	0	372	23	39	350	22	31
9	164	16	0	202	18	39	190	18	29
10	0	11	0	0	13	39	0	12	26

- Under Basis (i) Best Estimate, profit each year is zero as the liability at outset exactly supports expected future cash flows. Under Bases (ii) Conservative 1 and (iii) Conservative 2, the liabilities are conservative so exceed the value of expected net outgo. In both cases, a loss arises in Year 1 reflecting the cost of establishing the conservative reserves. These reserves are released as the business runs off and generate profits in subsequent policy years.
- The present value of profits is zero under each basis. Exercise: Why are the profits all zero?
- Liabilities under Bases (ii) and (iii) are conservative and hence larger than the Best Estimate basis. Thus, assets backing the liabilities generate more interest under the conservative bases when compared with the Best Estimate basis.
- It is worth comparing the pattern liability run-off and release of profit between Conservative Bases 1 and 2. Liabilities run-off more quickly and profit is therefore released earlier under Conservative Basis 2. This result suggests that, in earlier years, the value of margins based on additional expenses under Basis 2 is higher than the value of margins based on additional claims under Basis 1. This is reversed in later years. Looking at the supporting spreadsheet, mortality rates triple from the start to the end of the projection. Understanding and explaining changes in patterns of emerging profit and other items is an important part of the validation of results of a projection and can provide valuable insights.

- As the discount rate for valuing profits is the same as the assumed interest rate, the value of profits at the assumed discount rate is the same under each basis. The valuation basis affects the measurement (emergence) of profit from year to year but not the total value of profits generated, which is affected only by the business experience, claims, expenses, lapses and so on.

Exercise 5.17

The student should verify that the present value of profits at the assumed discount rate is the same under each basis. Does the present value of profits remain equal if a different discount is used? Why / why not?

- If experience was to vary from expected, this would affect each basis equally. For example, if expenses were $100 higher than expected in Year 5, profit for Year 5 would be $100 less under each basis. The present value of profits under each scenario would still equal one another.

Exercise 5.18

How would you adjust the spreadsheet to calculate the value of liabilities at the end of Year 5 under Conservative Basis 1 more accurately, taking into account the best estimate mortality rates to the end of Year 5? What difference does the adjustment make to the value of liabilities at the end of Year 5? Is this likely to be material in this example?

5.4.3. Stepped premium term insurance

Table 5.4a shows realistic projected cash flows for a 10-year non-profit stepped premium term insurance policy with a $400,000 sum insured. A stepped premium term policy is similar to a level premium term policy except that the premium, instead of being level each year, increases with age. Since the premium increases with age, premium income and claims outgo are much more closely matched each year than for a level premium term policy.

Exercise 5.19

The above example states that the stepped premiums increase with age but it is silent on whether the future rates are guaranteed or discretionary.

(i) Explain what is meant by *guaranteed* and *discretionary* rates.

(ii) Would your best estimate assumptions differ between guaranteed rates and discretionary rates?

The pricing basis used is the same as that for the previous level term example.

As before, cash flows are shown before interest, premiums are payable annually in advance, expenses are incurred at the start of the year and claims are paid at the end of the policy year.

As this is a stepped premium policy, the risk premium (i.e. the premium calculated ignoring expenses and profit) increases in line with age-related increases in mortality. As in the previous example, the office premium, shown in Table 5.4a, allows for the value of initial expenses and the present value of renewal expenses.

Although the expense assumptions and commission rates are the same, the amounts of expenses shown are different than in the previous example. This is because, under a stepped premium term, premiums are lower initially than under an equivalent level premium policy and increase in future years with age. Therefore, the dollar amount of a flat 20% commission is lower in earlier years under a stepped than a level premium. This is reversed in later years.

For example, the expected premium income in Year 1 is $584 with commission thereon of $117; whereas in the previous example, the expected premium income in Year 1 was $840 with commission thereon of $168. The respective projected premium income amounts in Year 10 are $553 and $307. In this stepped premium example, the age-related increase in premiums causes premium income to remain relatively flat, despite the run-off of the business with claims and lapses.

Table 5.4a also shows interest on assets. This is one year's interest on items assumed to be received or paid at the start of the year; i.e., premiums less expenses. Claims are assumed to be paid at the end of the year and do not contribute to interest on cash flows over the year. The materiality of interest on cash flows is discussed below.

Table 5.4a Net cash flows

Year	Premiums	Claims	Expenses	Net cash flow	Interest on assets	Net cash flow including interest
1	584	-428	-187	-31	12	-19
2	558	-409	-173	-24	12	-12
3	537	-394	-163	-20	11	-9
4	531	-390	-157	-15	11	-4
5	529	-388	-152	-11	11	0
6	528	-387	-148	-7	11	4
7	528	-387	-145	-4	11	7
8	529	-388	-141	-1	12	11
9	531	-390	-139	3	12	15
10	533	-391	-137	5	12	17

Table 5.4b shows the value of liabilities using three different valuation bases. These are the same as in the previous example:

- basis (i) is a best estimate or realistic basis: this is the pricing basis shown above although initial costs will have been spent and therefore don't affect liabilities;
- basis (ii) (Conservative Basis 1) is a conservative basis where expected mortality rates are increased by 10%; and
- basis (iii) (Conservative Basis 2) is also a conservative basis where expected expenses are increased by 85%.

As before, the value of liabilities at each year end are calculated as the present value of expected future outgo less income; i.e., a gross premium projection liability.

Exercise 5.20

Show that the realistic retrospective reserve agrees with the realistic prospective reserve.

Also, as in the previous example, the assumed experience used to determine profit under all three valuation bases is the same. The assumed experience is the best estimate or realistic basis. The same cash flows, as shown in Table 5.4a, are used in determining profit under each basis. The interest column includes interest on net cash flows (shown separately in Table 5.4a) plus one year's interest on reserves at the start. Reserves at the start are equal to the value of liabilities at the prior year end.

Table 5.4b Liability and profit on different bases

Year	Best Estimate Basis			Conservative Basis 1			Conservative Basis 2		
	Liability	Interest	Profit	Liability	Interest	Profit	Liability	Interest	Profit
0	0	0	0	338	0	-338	354	0	-354
1	-19	12	0	286	22	43	284	23	61
2	-33	11	0	240	20	41	226	20	54
3	-42	10	0	200	18	39	176	18	48
4	-47	10	0	163	17	39	133	17	44
5	-49	10	0	129	16	39	96	15	41
6	-46	10	0	98	15	39	66	14	37
7	-40	10	0	70	14	39	41	13	34
8	-30	10	0	44	14	39	22	13	31
9	-17	11	0	21	13	39	9	12	29
10	0	11	0	0	13	39	0	12	26

- The opening liability under Conservative Bases 1and 2 is the value of the future conservative margins, discounted at the assumed discount rate. These are the same for both the level premium term and the stepped premium term examples, as the conservative margins and discount rates are identical under both examples.
- The negative liability indicates that expected income from Year 2 onwards exceeds outgo. The quantum of the (negative) liability values is small, as cash inflows and outflows each year are fairly well matched. Under stepped premium policies, premiums increase with age and are matched to expected claims costs each year. Also, under this particular example, commission rates are level each year. Term policies, both stepped and level, often pay higher initial commissions and lower ongoing commissions. The impact of higher initial commissions and expenses and the valuation methodologies needed to address these are covered are Module 6 (Profit).
- It may not be obvious why profit is zero whereas cash flows are largely negative. In these simplified examples, premiums are received at the start of the year and claims paid at the end. Interest earned on premiums is a material contributor to income.

- Although income and outgo are fairly closely matched under a stepped premium term policy, the small negative liability indicates that income and outgo are not perfectly matched. Assumed expenses are $70 per annum with 2% p.a. inflation. Future assumed increases in expenses will not match assumed increases in premium, which are driven by increases in mortality. Expenses, therefore, will comprise a larger percentage of the premium in earlier years than in later years. It can be seen in Table 5.4a that net cash flows are negative in earlier years and then become positive. The negative liability effectively "anticipates" these positive flows in future years.
- As in the previous example, Conservative Bases 1 and 2 include margins over best estimate assumptions. The assumed experience follows the best estimate basis, irrespective of the valuation basis adopted. Therefore, losses arise upfront due to the cost of establishing reserves, and profits are released thereafter as the reserves and conservative margins are released.
- The comparison of the run-off of reserves and release of profit between Conservative Bases 1 and 2 is similar to that of the previous example, and students should refer back to the comments made.

5.4.4. Non-profit endowment insurance

Table 5.5a shows projected cash flows, on a realistic basis, for a 10-year endowment policy with a $10,000 sum insured. Endowment insurance policies include a savings and a level premium term insurance component, although the two are not separately identified. Under this example, the policy owner agrees to pay a fixed annual premium of $ 899 at the start of each policy year for ten years. If the policy owner pays the premiums when due, the life company is contractually obliged to pay the sum insured of $10,000, either at the end of the 10-year term or upon the earlier death of the life insured.

Generally, endowment insurance policies also provide for the payment of an amount, referred to as a *policy benefit* or *surrender value*, if the policy is surrendered before the end of the term, here 10 years. The benefit payable will depend on the terms set out in the policy document and will likely be based on the original sum insured multiplied by a surrender factor. The surrender factor is likely increase with duration. Typically, the surrender benefit will be only a small percentage of the sum insured at early durations, increasing to closer to 100% at later durations.

While these types of policies are no longer sold in Australia, they are sold overseas, and the examples illustrate methods and techniques that have application in a range of situations.

Liability values under endowment insurance policies represent the value of both the savings and insurance components of the policy, although as mentioned earlier, the two components are not separately identified. Effectively, a portion of each premium is invested and the assets are used to pay the maturity benefit when due or the surrender benefit if the policy is surrendered early. Also, a portion of a notional risk premium is invested to support future insurance claims, when claims outgo exceeds the risk premium. Students can refer back to the level premium term example for a discussion on this.

The office premium, shown in Table 5.5a, allows for the value of initial expenses and the present value of renewal expenses. As with earlier examples, cash flows are shown before interest, premiums are payable annually in advance, expenses are incurred at the start of the year and claims are paid at the end of the policy year.

The pricing basis can be summarised as follows:

- mortality: 70% of IA95-97 ultimate rates for a male life, of attained age 55 exact at commencement of the policy;
- lapse rates: 15% in Year 1, 10% in Year 2, and 5% thereafter;
- initial expenses: $70
- renewal expenses: $50 p.a. from Year 2 onwards with an expense inflation rate of 2% p.a.;
- initial commission: 3% of the initial premium;
- renewal commission: 3% p.a. as a percentage of the premium received;
- interest: 3% p.a. assumed rate of investment earnings on assets invested;
- discount rate: 3% p.a. used to calculate the present value of future cash flows; and
- tax is ignored.

The projection term is 10 years. The projection summarises cash flows each year for a portfolio of identical policies all written at the start of Year 1.

Students should refer to the modelling spreadsheet for further details of the valuation basis and how it is applied in the model.

As discussed earlier, the examples presented in this module have been constructed to illustrate the application of projection techniques and the impact of different liability valuation bases on the emergence of profit. Pricing basis and assumptions are not necessarily indicative of those used in practice. In particular, higher sums insured and higher expenses might be expected in policies currently sold.

Table 5.5a Net cash flow

Year	Premiums	Claims	Expenses	Net Cash Flow
1	899	-25	-97	778
2	762	-117	-65	580
3	684	-99	-59	526
4	648	-129	-57	462
5	614	-159	-55	400
6	581	-187	-52	341
7	549	-215	-50	284
8	519	-241	-48	230
9	491	-267	-46	177
10	463	-5150	-44	-4731

As in earlier examples, the value of liabilities at each year end are calculated as the present value of expected future outgo less income i.e. a gross premium projection liability.

Table 5.5b shows the value of liabilities using three different valuation bases. The conservative bases differ from the conservative assumptions used in the term insurance examples. While endowment insurance includes an insurance component, the savings characteristics of the policy generally have the most significant impact on the calculation of liability values. For this reason, the Conservative Basis 1 uses lower assumed interest and discount rates. The conservative mortality assumptions used in previous examples will have much less impact on liability values (Exercise: students should verify the statement in the preceding sentence).

- Basis (i) is a best estimate or realistic basis: this is the pricing basis shown above;
- basis (ii) (Conservative Basis 1) is a conservative basis where the interest (expected future investment earnings) rate and the discount rate are decreased from 3% to 2% pa; and
- basis (iii) (Conservative Basis 2) is also a conservative basis where expected expenses are increased by 95%.

As in the previous examples, premiums exactly cover expected benefit payments or claims plus expenses. Table 5.5b includes columns on 'profit' for each valuation basis, defined here as the net cash flow plus interest less the change in liability over the year.

As in earlier examples, the assumed experience used to determine profit under all three valuation bases is the same. The assumed experience is the best estimate or realistic basis. The same cash flows, as shown in Table 5.5a, are used in determining profit under each basis.

Premiums are assumed to be received at the start and earn one full year's interest. The value of liabilities are at the year end. Reserves based on the value of liabilities earn one full year's interest in the following year. Opening liability values are shown as Year 0. Under the best estimate basis, the opening liability value is zero.

Profit is assumed to be earned at the end of each year, except that the loss on creation of opening reserves under Conservative Bases 1 and 2 occurs at commencement of the policies.

Table 5.5b Liability and profit on different bases

Year	Best Estimate Basis			Conservative Basis 1			Conservative Basis 2		
	Liability	Interest	Profit	Liability	Interest	Profit	Liability	Interest	Profit
0	0	0	0	278	0	-278	330	0	-330
1	802	24	0	1077	32	11	1073	34	68
2	1427	45	0	1693	53	18	1664	53	41
3	2015	62	0	2266	70	23	2222	69	38
4	2555	78	0	2785	86	29	2731	84	37
5	3048	93	0	3252	100	33	3195	99	35
6	3497	107	0	3669	113	38	3613	112	34
7	3901	120	0	4036	125	42	3988	123	33
8	4262	131	0	4356	135	45	4320	134	32
9	4581	141	0	4630	144	48	4609	143	31
10	0	150	0	0	151	50	0	151	30

- As in the previous examples, Conservative Bases 1 and 2 include margins over best estimate assumptions. The assumed experience follows the best estimate basis, irrespective of the valuation basis adopted. Losses arise upfront due to the cost of establishing reserves and profits are released thereafter as the reserves and conservative margins are released.
- Under basis (i), profit each year is zero as the liability at outset exactly supports expected future cash flows. Under Conservative Bases 1and 2, the liabilities are conservative so exceed the value of expected net outgo. Losses arise in Year 0 under Conservative Bases 1and 2, reflecting the cost of establishing the conservative reserves, and these reserves are released as the business runs off.
- Under Conservative Basis 1, the size of the interest margin, in dollar terms, is largely driven by the size of accumulated reserves, which is equal to the value of liabilities. The margins are, therefore, lower in earlier years and then increase, giving a later release of profit than under Conservative Basis 2, where margins are based on expenses.

5.4.5. Disability income insurance

Nature of disability income policies

Disability income policies are also referred to as *income protection policies*. Disability income cover provides a benefit, generally payable monthly, to replace normal income when the insured is disabled and unable to work. There is generally a waiting period, being a period that an insured life must be disabled before they are eligible to claim. Benefits are payable as long as the insured remains disabled and eligible to claim. Policies may cease paying benefits after a certain age, for example age 55 or 65, or after a maximum period, such a 10 year maximum benefit period. In the example below, benefits are payable to age 65.

There are a wide range of policy terms and conditions that impact the amount and cost of claims. For example, waiting periods can vary from two weeks to two years, and claims may be payable on disablement through accident only or accident *and* sickness. Similarly, benefit payments may be indexed and may be guaranteed or offset by other income, and maximum benefit periods may vary. These sorts of contract features need to be taken into consideration in valuing disability income policies.

Another factor that is important in the valuation of disability income business is the occupation of the insured. Claims rates and the expected cost of claims vary considerably by occupation. Occupation may change over an insured's lifetime and the valuation actuary needs to ensure that information used in the valuation is current and accurate.

The valuation of policy liabilities for disability income business has additional complications compared to lump sum business. The ultimate cost of a disability income claim is not certain at the time of claim and will depend on the length of time that the claimant is disabled and eligible to claim.

Disability income policies are generally divided into two distinct groups for valuation purposes:

- policies or lives that are not receiving claim payments and do not have an existing "open" claim at the valuation date. These are referred to as *active lives*; and
- policies that are receiving claim payments and have an "open" claim status at the valuation date. These are referred to as *disabled lives*.

Valuation of liabilities for active lives

A common method of calculating expected claims costs in the valuation of liabilities for active lives is through use of an "incidence and annuity" model. The modelled cost of claims in a period, for active lives, is the product of the assumed claim incidence rate over the period and the estimated average value of future payments for a claim arising during that period. Claims incidence rates are generally based on the age of the insured at the assumed time of claim.

The average value of future claim payments is calculated as the value of an annuity, where the annuity payment is the monthly income benefit payable. The value is calculated using annuity commutation formulae, taking into account the probability of recovery. The methodology should be familiar to students from Actuarial Mathematics topics in the Foundation course. The annuity value includes factors that reflect claim termination rates, claim indexation where applicable, claim processing expenses and the assumed discount rates. The annuity calculation would also reflect the waiting period, which is the minimum period of illness before benefits are payable, and the maximum benefit term. Alternatively, a projection can be used instead of an annuity commutation formula and provides more modelling flexibility.

The common method of calculating the value of future claim payments in the valuation of liabilities for disabled lives is similarly based on an annuity calculation, reflecting the average cost of future claims payments. No incidence rates are applied in valuing liabilities for disabled lives as the claim is known. Considerations in valuing liabilities for disabled lives are discussed later in this section.

An example of cash flows and liability values calculated under an incidence and annuity approach are summarised in Table 5.6. In the example, a projection is used to model expected future cash flows. Claims costs are calculated using an annuity factor applied to the monthly benefit at the time of claim. Students should ensure that they understand and can apply the techniques. Note that in the example, the cost of claims each year is not the amount expected to be paid in that year, but the total value of all future payments for claims assumed to arise in that year.

An "incidence and annuity" model implicitly assumes that each life can only make a single claim. Under this modelling simplification, when a claim terminates, the policy ceases. In practice, the terms of disability policies usually allow them to continue after the life insured recovers. Further periods of disability may occur and are more likely to occur than for policies that have never been on-claim. This does not mean that results are incorrect. This modelling simplification means that higher incidence rates should be used to reflect repeat claims.

Alternatively, a projection model that explicitly allows for multiple claims could be used. This is referred to as a "multi-state" model, as each policy can switch between being on-claim and off-claim throughout the term of the projection. More complex modelling may be necessary for policies with additional benefits. For example, if a death benefit is provided, a projection of future mortality rates will also be required.

The extent to which detailed features are captured within models, versus the use of averaging or compensating adjustments, will be a matter of judgement. A balance must be achieved between competing considerations. These include the additional costs of greater modelling complexity, the materiality of the result and the accuracy gained.

Valuation of liabilities for active lives: illustrated example

The purpose of this example is to illustrate the application of projection models and the gross premium methodology to the valuation of disability income policies for active lives.

Table 5.6 shows cash flows each year and liability values at year end for a 10-year level premium disability income policy with a benefit period to age 65 on a male life aged 30 exact at commencement. The sum insured is a monthly benefit of $10,000.

Once again, the purpose of the example is to illustrate the methodologies and concepts, and the pricing basis and assumptions are not necessarily indicative of those used in practice. The example is for a level premium policy, but stepped disability income policies are also sold and are more common in Australia.

The pricing basis for this example can be summarised as follows:

- claims incidence rates: Sample incidence rates as per spreadsheet based on a one-month waiting period;
- claims continuance rates: Sample claims continuance rates as per spreadsheet, based on a one-month waiting period;
- occupation: Clerical;
- lapse rates: 15% in Year 1, 10% Year 2 and 5% p.a. thereafter;
- initial expenses: $80, renewal expenses: $80 p.a. from Year 2 onwards with an expense inflation rate of 3% p.a.;
- claims expenses; 3% of the cost of claims;
- initial commission: 10% and renewal commission: 10% p.a., both calculated as a percentage of the premium received;
- interest and discount rates: both 5% p.a. The interest rate is the assumed rate of investment earnings on assets invested. The discount rate is the rate used to calculate the present value of future cash flows.
- Inflation rate: 3% p.a. This is applied to expenses and to the monthly benefit sum insured, the monthly income benefit payable on disablement is not indexed.
- Tax is ignored.

Valuation basis

The valuation basis is the pricing basis shown above, which can be considered a best estimate or realistic basis. The projection term is 10 years. The projection summarises cash flows each year for a portfolio of identical policies all written at the start of Year 1.

Premiums are assumed to be received at the start and earn one full year's interest. The value of liabilities shown are at the year end. Reserves based on the value of liabilities earn one full year's interest in the following year. Profit is assumed to be earned at the end of each year.

Students should refer to the modelling spreadsheet for further details of the valuation basis and how it is applied in the model.

Table 5.6 Active life valuation

Year End	Premium	Comm	Expenses	Cost of Disability claims	Total	Liability Values at Year End for Inforce	Interest	Profit or surplus
0								
1	538	-54	-80	-307	96	145	22	0
2	468	-47	-70	-288	64	234	25	0
3	432	-43	-64	-284	40	303	28	0
4	421	-42	-63	-301	15	348	31	0
5	409	-41	-61	-318	-10	371	33	0
6	398	-40	-59	-339	-40	364	34	0
7	387	-39	-58	-363	-72	325	33	0
8	376	-38	-56	-386	-103	252	30	0
9	366	-37	-54	-409	-134	144	26	0
10	355	-36	-53	-431	-164	0	21	0

- The profit each year is zero, after allowance for interest on cash flows and reserves. In the early policy years, expected premiums exceed claims and expenses, and this is reversed in later years. The value of policy liabilities builds to a maximum of $371 at the end of Year 5 and thereafter reduces to zero by the end of the 10-year term.

The cost of claims shown above, for example, $307 for Year 1, is the discounted value of all future monthly income payments for claims arising in that year. These amounts would not necessarily be paid within that year. Income payments for claims arising in a year may continue over a number of years and would run off according to the expected claims continuance rates. This is different to lump sum business where claims arising in a year would be expected to be settled fully in that year, subject to possible reporting and settlement delays.

The reserves that would be held at the end of each year for active lives are the liability values shown in Table 5.6. It is important to note that the total reserves for disability income business are made up of the reserves for active or healthy lives and those for disabled lives at the date of valuation. For example, at the end of Year 10, the value of liabilities, therefore, the reserve for active lives, is zero, as all policies have expired. Reserves would still be required, however, to cover the expected cost of future claim payments for lives that became disabled at some point during the period when they were covered and are still eligible to claim. A part of the cost of claims for Year 10, $431, would have been paid during that year and the remainder would be held as a reserve at year end and invested. The proceeds would be used to make ongoing payments for those still disabled at year end. Similarly, for the cost of claims arising in Year 9 and so on for claims arising in prior years.

Reserves for disabled lives plus accumulated earnings thereon are invested and the proceeds used to make future claim payments for lives that became disabled and are still eligible to claim at the year-end valuation date. As discussed earlier, the valuation of disability policies with claims under payment at the valuation date follows a similar approach to that used for the disability annuity value component in valuing liabilities for active lives. This are discussed in the next section.

One further point to note in the spreadsheet calculations is that claims termination rates and annuity factors for valuing claims are presented and calculated in five-year age intervals. Results between these five-year intervals are obtained by interpolation. Disability income claims continuance rates need to be categorised in many ways: age, duration, occupation, benefit period and so on. For this reason, disability income claims continuance rates are often grouped and models need to be able to use grouped data. Grouping categories ensures that statistical errors in the rates determined for each category are within acceptable bounds.

Valuation of claims for disabled lives in the course of payment (open claims)

Reserves for policies with disability claims under payment at the date of valuation are referred to by a number of terms, often used interchangeably: *Open Claims Reserves*, *Claims in the Course of Payment* (CICP) and *Disabled Lives Reserves* (DLR). In a valuation, policies that are currently disabled are often modelled, valued and reported separately to active lives.

Although the claims for these policies are certain, the eventual duration and cost are not. Claims will continue if the insured continues to be disabled and eligible to claim. The valuation of these liabilities follows a similar approach to that used for the disability annuity value component in valuing liabilities for active lives. A difference is that no incidence rates are required as policies have already claimed. Claim continuance rates, also referred to as *claims termination rates*, are likely to be categorised by factors such as the age of the life insured when the claim first occurred and the duration of the claim. Lives that are older at the time of claim tend to take longer to recover.

The liability for an existing claim will be the monthly benefit multiplied by an annuity factor plus an allowance for claim processing expenses. The annuity, in addition to the rating factors listed above, will also reflect any outstanding waiting period and the remaining benefit term.

Exercise 5.21

Open disability income claims at the valuation date may also be valued using case estimates provided by claims managers and other experts. What might be the advantages and disadvantages of using case estimates over actuarial estimates, and in what circumstances would you consider their use?

5.5. Reinsurance

Reinsurance is dealt with in-depth in the LI&R Product Development subject and in the Application subjects. This section is a brief introduction and shows how reinsurance may impact on the value of liabilities.

5.5.1. Main types of reinsurance and their impact on liability values

Life companies use reinsurance to transfer risks unwanted to the reinsurer. Typically, a life company may want to reduce the uncertainty and volatility of its insurance claims. The reinsurer will be seeking a profit so that the main consideration relates to the amount of capital that is required to support the balance sheet, with or without reinsurance. Reinsurance can also provide access to technical expertise, systems and risk management.

Financial reinsurance has historically been available to support the writing of new business. Many designs were available and they attempted to circumvent prudential rules. Their use is limited where valuations are based on realistic bases.

Reinsurance contracts or policies are usually made with a dedicated reinsurance company but could also be made with other direct life insurance companies. Reinsurance arrangements can be long-term, lasting until maturity or cancellation of all policies covered under the arrangement, or short-term, renegotiated or renewed annually or more frequently. The company pays reinsurance premiums and the reinsurer pays the company a proportion of claims costs.

There are two main categories of reinsurance: *proportional* and *non-proportional*.

Proportional reinsurance is where the amount of reinsurance is determined as a proportion of the sum insured for a given underlying risk.

The main categories of proportional reinsurance are:

- **Quota share**, where claims costs are shared in proportion, such as 40% paid by the reinsurer and 60% paid by the insurer.
- **Surplus**, where the insurer covers the cost of the first part of a claim, say claim amounts of up to $150,000, or for income protection insurance, say claim amounts of up to $7,000 per month, and the reinsurer makes a payment to the insurer to cover the cost of the remainder of the benefit.
- **Co-insurance**, which is like quota share except that the reinsurance premiums are based on the premium rates for the underlying policies, rather than based on separate reinsurance premium rates. This is also referred to as *original terms* reinsurance.

Non-proportional reinsurance is where the reinsurer makes payments when the total (aggregate) claims cost for a portfolio of included policies exceeds an agreed threshold over an agreed time period. In contrast to proportional reinsurance, non-proportional contracts are at an aggregate rather than individual risk level. Non-proportional arrangements may include upper limits on the reinsurer's liability to make payments. Industry terms used to describe these arrangements are *stop loss* and *catastrophe* cover. Catastrophe cover, as the name may suggest, generally has a high threshold and measures aggregate portfolio claims costs over a short time period. It may be limited to certain conditions, such as claims arising due to the spread of a pandemic virus.

Reinsurance arrangements can be tailored for each situation, so the number of possible variations is boundless.

Reinsurance arrangements often have a large impact on future cash flows under policies and therefore need to be incorporated into liability valuations. Results may be calculated and presented net of reinsurance impacts or gross of reinsurance, with reinsurance cash flows valued and presented separately.

Non-proportional reinsurance provides cover in more extreme adverse situations, representing the tail of the distribution of probabilistic outcomes. Valuations using stochastic methodologies may, therefore, be more appropriate for this type of reinsurance.

5.5.2. Reinsurance and credit risk

A life company pays reinsurance premiums and receives payments contingent upon the reassurance claims event. The expectation of benefits, termed *recoveries*, from the reinsurer impacts liability values. The expected (net of reinsurance) cost of future claims will be lower where polices are reinsured. Also, expected future income will be lower because of payments to the reinsurer.

Reinsurance creates a credit exposure for the company, meaning that failure of a reinsurer to meet its obligations can financially harm the company. The exposure can be quite significant, for instance, where claims may be settled over many years, such as for disability income and group risk. One way to reduce credit exposure to a single reinsurer is to split the arrangement between two or more reinsurance companies.

Reinsurance and the management of risk and capital are covered in later modules. For the valuation of liabilities, any doubt over the future payment of reinsurance recoveries should be reflected in adjustments to liability values.

5.5.3. Reinsurance disclosure example

The table below shows an example of reinsurance liabilities and obligations shown separately from the gross policy liabilities. The value of life insurance policy liabilities net of reinsurance for 2017 (−$222.97 m) is equal to the gross value (−$207.63 m) plus the value of reinsurance (−$15.34 m). The value of reinsurance for 2016 is very different (+$0.70 m). Reinsurance reduces the value of policy liabilities (makes them more negative). At this stage, the student may find the negative values placed on liabilities in company reporting confusing. The negative policy liabilities reflect the effect of margins for the recovery of acquisition costs. This topic is covered in Module 6 (Profit).

Clearview Annual Report 2017 – liability disclosure

	Consolidated	
	2017 $'000	2016 $'000
Life insurance policy liabilities		
Opening gross life insurance policy liabilities	(203,830)	(156,641)
Movement in outstanding claims	18,077	8,185
Decrease in life insurance policy liabilities reflected in the income statement	(21,879)	(55,374)
Closing gross life insurance policy liabilities	**(207,632)**	**(203,830)**
Total gross policy liabilities	**969,658**	**948,724**
Reinsurers' share of life insurance policy liabilities		
Opening balance	703	2,233
Movement in outstanding reinsurance	(15,871)	(12,326)
(Increase)/decrease in reinsurance assets reflected in the income statement	(170)	10,796
Closing balance	**(15,338)**	**703**
Net policy liabilities at balance date	**954,320**	**949,427**

(l) Reinsurance

Amounts paid to reinsurers under life insurance contracts held by ClearView Life are recorded as an outward reinsurance expense and are recognised in the statement of profit or loss and other comprehensive income from the reinsurance premium payment due date. Reinsurance recoveries receivable on claims incurred are recognised as revenue. Recoveries are assessed in a manner similar to the assessment of life insurance contract liabilities. Recoveries are measured as the present value of the expected future receipts, calculated on the same basis as the life insurance contract liabilities.

5.6. Key learning points

Valuation method, basis and model

- Policy liability valuation requires selection of an appropriate method, basis and model.
- Future experience is only known as it unfolds and is not affected by the valuation approach. The only certainty is that experience will be different to that assumed.
- Professional judgement is required in selecting a valuation approach. An actuary should ensure that all material matters are addressed. A range of items should be considered, including the purpose of the valuation, regulations, the products to be valued and consistency between asset and liability valuations.

Valuation bases

- A realistic or best estimate basis does not deliberately over or understate expected cash flows. Any margins for conservatism are explicitly added on top.
- A conservative valuation basis includes margins and, therefore, places a higher value on liabilities than a best estimate basis.

Valuation methods

- The gross premium method explicitly allows for all outgo and for the future receipt of the actual premium payable. The net premium method ignores expenses and future profits and calculates premiums using the valuation basis.
- A policy liability can be calculated either by retrospective (backward-looking) or prospective (forward-looking) methods. A retrospective approach is commonly used for group risk, unit-linked and participating business.
- Deterministic valuations use a single estimate for each assumption. In a stochastic valuation, inputs take the form of probability distributions. Stochastic projections are useful for valuing asymmetric risks.
- IBNR liabilities are commonly calculated using a chain ladder method. RBNA liabilities may be calculated with reference to case estimates or using statistical methods.
- Disability income policies are generally valued separately for active and disabled lives using an “incidence and annuity” model.

Reinsurance

- Life companies use reinsurance to transfer risks and volatility to the reinsurer. Reinsurance can also provide relief from new business strain and access to technical expertise.
- Reinsurance can have a large impact on future cash flows under policies, and therefore need to be incorporated into liability valuations. Results may be presented net of reinsurance or the impact of reinsurance may be presented explicitly.
- Reinsurance arrangements can be tailored for each situation, so the number of possible variations is boundless.
- Reinsurance may be proportional (e.g. quota share, surplus and co-insurance) or non-proportional (e.g. stop loss or catastrophe cover).
- Potential failure of a reinsurer creates a significant credit exposure for the company.

5.7. Answers to exercises

Exercise 5.1

Amend the equation of value to represent a unit-linked contract. (Hint, you may want to consider separate equations for policy owners and shareholders

Answer:

In the Associateship course, unit-linked contracts were described as an example of an unbundled contract. We revisit that concept in this Module.

The unbundling refers to the separation of shareholders' interests and policy owners' interests. Note that the equations hide/brush over a significant amount of detail (e.g. we ignore what happens on surrender).

Policy owner

Premiums allocated to the purchase of units * annuity factor = Account Balance * assurance factor + fees * annuity factor

Shareholder

Fees * annuity factor + unallocated premiums * annuity factor = Initial Expenses (IE)+ Renewal expense (RE) * annuity factor + (Benefit - Account Balance) * assurance factor

Exercise 5.2:

Why is a deterministic projection using best estimate assumptions not used to model variable annuities with minimum maturity guarantees?

Answer:

Minimum maturity guarantees are asymmetric risks to the company. They have a cost only when the total return over the guarantee period is below the guaranteed rate.

A deterministic projection would incorporate a mean expected return, which would be above the guaranteed rate, so would not capture the cost of such guarantees.

A stochastic projection should be used, or adjustment made to the liability calculated on in a deterministic projection, to reflect the estimated cost of the guarantee.

Exercise 5.3:

Describe the steps you could take to ensure that your liability valuation includes all material matters.

Answer:

- Review the documentation from the previous valuation to determine the material matters identified and how they were treated.
- Discuss any changes to business or products with relevant company managers or, for a retirement fund, discuss any changes since last time with managers, trustees and the sponsoring employer. Such a discussion will be more effective if the actuary has a list of possible issues that may have arisen, in order to prompt a more complete response. The sorts of questions would include:

    1. Any changes to products or pricing that have been made or are in various stages of planning?
    2. Changes to management philosophy or approach to managing claims?
    3. Changes to systems or agreements with service providers?
    4. Any changes to reinsurance arrangements?

- Consider changes to standards or regulations since the previous valuation and how these may impact the valuation.
- Consider any other changes within the industry (competitive environment, industry issues).
- Review experience since the previous valuation and any analysis thereon and consider how this might impact the current valuation.

Exercise 5.4:

Explain why it is important to apply consistent approaches in measuring policy liabilities. You should consider consistency over time and consistency between companies.

Answer:

Consistency over time

- Consistency does not mean exactly the same at each valuation. Where changes are required, these should be justified and explained. If a valuation approach has been well considered, it should be relevant and able to be applied consistently in successive valuations.
- The use of a consistent approach helps to ensure that results are not manipulated. Valuation of policy liabilities impacts shareholder capital required and the emergence of profit from year to year. It would not be appropriate that these be subject to short term manipulation, by selecting a methodology or assumptions that "engineer" a desired outcome.

Consistency between companies

- Regulators, and potential customers or investors will want to be able to compare important measures between companies such as:
    - security of policy or member obligations;
    - amount of capital above minimum liability values; and
    - estimated profit, which is affected by the value placed on outstanding liabilities.

Exercise 5.5:

List the basis assumptions in relation to valuing a participating endowment assurance.

Answer:

Mortality split by factors (gender, smoker, ...) (Valuation will be more 'broad-brush' than pricing.)

Lapse by policy duration.

Investment earnings and discount rate.

Renewal expenses plus termination expenses plus relevant inflationary growth.

Future reversionary bonus rates and terminal bonus if applicable.

Acquisition costs if valuation basis includes margin for recovery of these.

Tax

(Policy details are data items and not assumptions.)

Exercise 5.6:

Why would the liability be too low if there was no allowance for future expected bonus?

Answer:

The liability is the present value of future benefits and expenses less the present value of the premiums payable.

The premiums payable are 'loaded' for an expected bonus. If the benefit did not allow for future bonuses then the liability will be too low as the PV of premiums includes an allowance for expected bonuses.

Exercise 5.7:

What is a 'loss leader'?

Answer:

A loss leader is a product priced to make a loss on a best estimate basis. A company obviously cannot continue as a viable concern if products are not priced to make a profit. There may be situations where a smaller product line is sold in conjunction with more profitable products and is priced to make a loss as a marketing tool, to encourage cross sales of more profitable product.

The Product Development subject covers pricing considerations such as ensuring that sales assumptions of more profitable lines are not too optimistic or the implications of pricing on a marginal cost basis. Actual policies written, not expected, will be reflected in the valuation data. Larger than anticipated sales of a loss leader would lead to higher valuation reserving requirements to cover expected future losses.

Exercise 5.8:

See question text in box

Answer:

Use the following assumptions to create both a net premium and gross premium liability for a ten-year level premium term assurance. Interest and mortality is expected to follow a Normal distribution. Investigate the sensitivity of the valuation methods and state the confidence interval for your results in each sensitivity test.

All contracts sold to non-smoking males on their 30th birthday.

Sum Insured $400,000

Interest: N(0.04, 0.1)

Mortality: N(80% of IA95-97 UltM, 0.03) (This aligns with the mortality tables in the Module 5 spreadsheets rather than the table in the textbook.)

Initial Commission: 90% of the first year's premium

Renewal commission: 5% of each subsequent premium

Initial expenses: $200

Renewal expenses: $50 per annum incurred at the start of each policy year, excluding the first year.

Claim expenses: $300.

Expense inflation is 2.5% per annum.

Answer:

To be completed.

Exercise 5.9:

You may want to revise the Life Contingencies subject and demonstrate that ((_t^)V 〖(_x^)+ NP)(1+i)〗 ^ = q_(x+t)^ +(_t+1^)V _x^ p_(x+t)

Answer:

Proof

$$
\begin{aligned}
& & ({}_tV_x + P_x) &= (A_{x+t} - P_x\,\ddot{a}_{x+t}) + P_x \\
\text{but} & & A_{x+t} &= vq_{x+t} + vp_{x+t}A_{x+t+1} \\
\text{and} & & \ddot{a}_{x+t} &= 1 + vp_{x+t}\,\ddot{a}_{x+t+1} \\
\text{so} & & ({}_tV_x + P_x) &= vq_{x+t} + vp_{x+t}A_{x+t+1} - P_x\,(1 + vp_{x+t}\ddot{a}_{x+t+1}) + P_x \\
& & &= v(q_{x+t} + p_{x+t}\,(A_{x+t+1} - P_x\,\ddot{a}_{x+t+1})) \\
& & &= v(q_{x+t} + p_{x+t:t+1}V_x) \\
\Rightarrow & & ({}_tV_x + P_x)\,(1+i) &= q_{x+t} + p_{x+t:t+1}V_x
\end{aligned}
$$

Exercise 5.10:

Why are negative liabilities not appropriate for prudential capital adequacy valuations.

Answer:

A negative liability on the balance sheet is the same as an asset. It arises, for example, if the value of expected future premium income is higher than the value of expected claims and expenses.

A prudential capital adequacy valuation needs to consider the net asset position (i.e. assets in excess of liabilities – defined more precisely in Module 14) in a range of adverse scenarios, such as where the company ceases to operate or experiences large numbers of policy lapses. For example, consider a company with two products, P1 and P2, say, and end of year policy liabilities as follows:

PS1 100

PS2 -80

Total 20

The company holds assets of 20, equal to the aggregate of the liabilities. Assume that the amount payable on lapse is zero. If a large number of policy owners under P2 were to lapse, unexpectedly, within a short time frame, then the company would have insufficient assets to cover the value of liabilities.

Exercise 5.11:

Suppose life company A is a relatively young proprietary company and premium income is growing rapidly. Suppose company B is a well-established mutual organisation that has some premium growth. Consider the effect of introducing a Zillmer adjustment on the liabilities. Project forward the balance sheet for a few years, assuming growth continues.

Answer:

The zillmer adjustment is formally represented in the following formula.

$$(SI + RB)\, A_{x+t} - \left(PNP + \frac{I}{\ddot{a}_x} \right) \ddot{a}_{x+t}$$

where $I/\ddot{a}_x$ is the Zillmer adjustment, PNP is the net premium, SI is the sum insured and RB is the declared bonus, which would be zero for non-participating polices.

The pure net premium has no allowance for expenses. By using the zillmer adjustment, a portion of the adjusted net premium is assumed to contain a margin for recovery of initial expenses. It is obvious from the formula that reserves are higher at each duration without the zillmer adjustment.

The initial expense, I, will include commissions and allocated administrative costs and will vary by policy. The zillmer adjustment will not exactly reflect initial costs, but will reduce initial reserving requirements, thereby reducing or removing the impact on profit or surplus of initial costs. The reserving basis does not affect actual profit or surplus only the timing. The young growing company, A, can offset acquisition costs through lower reserves and therefore will not require as much capital to support sales in early years. The surplus emerging in later years will be less than would arise if the company had not used the zillmer adjustment.

For the mature company, B, the use of a zillmer adjustment may not have much impact. More mature policies are likely to be releasing large surpluses each year and there may be no need to change the pace of release. New policies may be making negative contribution to surplus. With the adjustment, the difference in release between old and new policies may change but overall the result may be similar. The existence of "some" premium growth, as described, may cause some new business financing issues, with negative surplus arising from new business.

Company B is a mutual company, so unlike A, will not have access to shareholder capital to fund new business growth. Therefore, although the dollar impact of introducing a zillmer adjustment may be smaller than A, the impact on the company may be significant.

Exercise 5.12:

1. Briefly justify two conditions that are required for the equivalence between the retrospective and gross premium reserves of a non-profit endowment assurance at the start of the nth policy year.
2. How would you change your answer if the contract was replaced by a participating contract?
3. Explain why equality is unlikely.

Answer:

1. The conditions for equivalence are:

    I. The mortality, interest and expenses assumptions are the pricing assumptions used to derive the gross premium.

    II. The gross premiums were calculated by equating the present values of income and outgo, allowing for any desired profit margins.

2. In addition to the conditions above, the two would be equivalent only if the same assumed bonus scales are used in the premium calculation and the future benefits under the prospective reserve. Also, these assumed rates are the declared rates in the retrospective reserve calculation.

3. In practice, a prospective reserve will use assumptions suitable for the remainder of the policy term. The retrospective calculation will use assumptions derived from experience to date. The two will be different and will differ from the original premium basis. For par business, the declared rates will vary from those assumed in pricing.

Exercise 5.13:

Suppose a unit-linked contract offered an allocation to units at 100% for all years, except year 15, where the allocation was 120%.

Calculate the non-unit reserve. You may make as many simplifying assumptions but they need to be justified.

Write down a general approach for calculating non-unit reserves.

Answer:

If you had been provided with data and parameters, then this question would be a Foundation (Part 1) question. It involves higher-order skills as you must make judgements on what are sensible assumptions.

Try and think what is in the question and how that may drive your assumptions.

1. Is it a regular premium contract? It can't be a single premium contract.
2. Can premiums vary? Possibly but that leaves a selection risk (e.g. pay $1000 p.a. for 14 years and then pay $1m.) Assume level premium.
3. What's a non-unit reserve? It can cover a shortfall of income versus outgo but let's restrict discussion to the specific point in the question (i.e. the 120% allocation at year 15). A 'sensible' assumption is that fees match expenses.

We need to hold 0.2P at time t = 15, where P is the assumed level premium.

The simplest approach is to discount the required benefit by the non-unit reserve discount rate. That would require a reserve at outset equal to 0.2Pv15. This could be reduced by allowing for lapses i.e. hold 0.2Pv15(lx+15/lx), where the change in the number of lives allows for lapse but ignores mortality.

General approach (Life contingencies revision)

Let's begin with a brief recap of what we are trying to achieve.

Suppose the profit vector (the expected profits arising in future years for policies in force at policy inception) is (a1, a2, a3, ..., an). If one, or more, of the a's are negative then income in that year is insufficient to pay outgo. A reserve needs to be set up, at the start of the preceding period, to zeroise the negative net cash flow. The process below outlines how to set up the required non-unit reserves.

1. Start with the latest negative cash flow, ai, say.
2. The reserve at the start of the i-1 period $_{i-1}V = v\ a_i$
3. If $a_{i-1} < 0$, then we need a reserve at the start of the i -2 period:

   $$_{i-2}V = v\ a_{i-1} + v^2 a_{i-1}(ap)_{x+m-2}$$

4. Keep repeating step 2 until either the start of the contract is reached or a positive ai is reached where ai is sufficient to pay for the required reserve.

Exercise 5.14:

If the loss ratio implicit in pricing business for 2017 was materially different from the historical average, how would that affect the ratio to be used for modelling IBNR?

Why might the two be different?

Answer:

a) The IBNR using a chain ladder method uses historical average loss ratios to estimate the cost of outstanding claims for the latest incidence year. If there is a change in pricing terms for new schemes, then the pricing loss ratios are more appropriate for business recently repriced rather than historical averages. The claims experience in the latest incidence year will likely reflect experience for schemes priced on historical pricing bases, some of which will not be repriced to reflect the latest pricing terms. Therefore, the actuary may need to modify the approach. Loss ratios may be determined separately for recently repriced schemes. Alternatively, an overall average loss ratio can be determined, taking into account the proportion of repriced schemes.

b) Product pricing is covered in the Product Development subject so this is a brief answer. When valuing group schemes, the actuary needs to be aware that competitive pressures can have an impact on pricing, therefore expected loss ratios.

Exercise 5.15:

How reliable would the Basic Chain ladder method be, as applied in the example, under the following conditions and how might the approach be adapted:

a. Exposure (premiums written) had increased significantly over the investigation time period due to a few very large new schemes

b. Reporting requirements or conditions under policies changed significantly over the period

c. Loss ratios show a strong increasing trend over time

Answer:

a) Claim run-off patterns can be affected by a number of factors, including type of cover (e.g. death, salary continuance), type of industry and the processes of the scheme administrator, usually a retirement fund. The new schemes may represent a large proportion of the business and claims run-off patterns may be quite different from existing schemes. The actuary may seek to obtain experience data from the scheme's previous insurer to assist in estimating claims run-off rates. The reliability of externally sourced data can be problematic benchmarking against the company's own schemes may be useful.

b) Reporting delays arise both to delays in group scheme members reporting to the scheme and delays in the scheme reporting to the insurer. They can also arise because the claim does not occur until much later than the exposure giving rise to a claim. (e.g. asbestos claims) The rules for reporting can have a significant impact on delays. Some cover types, such a TPD, may have a 6 month, or 12-month minimum period before a claim is payable. Reporting rules will impact some but not all claims delays. The actuary needs to be aware of and adjust for any significant changes to reporting rules.

c) The chain ladder method utilises the pattern of reporting delays from past claims while still taking into account actual claims experience to date for each incidence year. Therefore, increasing loss ratios over time will be reflected in the claims continuance factors derived from experience. If the change is due to deliberate pricing / repricing strategies, the actuary needs to ensure that this is appropriately reflected as discussed in question 5.14.

Exercise 5.16:

(i) Provide an example of mitigating circumstances.

(ii) In your opinion, what is a reasonable period between the date of death and payment of a death benefit?

Answer:

(i) Non-disclosure of a serious condition affecting the risk of death. Death by suicide may be excluded although this is usually limited to some period – e.g. 13 months after contract outset.

(ii) If can be expected that, in most circumstances, if all relevant information (e.g. death certificate) has been provided, the assessment and determination of a valid claim should be a quick process. Since a death payment will be paid to a beneficiary, establishing the entitlement of an individual or party to receive the insured benefit may cause some delays.

Exercise 5.17:

The student should verify that the present value of profits at the assumed discount rate is the same under each basis. Does the present value of profits remain equal if a different discount is used? Why / why not?

Answer:

The present value changes with the discount rate. Profits that are delayed are worth less. This is because the assumed fund earning rate (the rate earned on retained profits) is less than the discount rate.

Exercise 5.18:

How would you adjust the spreadsheet to calculate the value of liabilities at the end of year 5 under Conservative Basis 1 more accurately, taking into account the best estimate mortality rates to the end of year 5? What difference does the adjustment make to the value of liabilities at the end of year 5. Is this likely to be material in this example?

Answer:

Adjust decrement rates in dx factors for years 6 -10, cells m10 to m14

Liability calculated on conservative basis without adjustment: $666.6

Liability using BE mortality to the end of year 5: $667.02

The difference is small as mortality rates are around 0.001 to 0.002 at these ages. While higher mortality has a material impact on expected claims costs, therefore the value of liabilities, the additional mortality has minimal impact on assumed proportion of portfolio still in force.

Exercise 5.19:

The above example states that the stepped premiums increase by age but it is silent on whether the future rates are guaranteed or discretionary.

(i) Explain what is meant by guaranteed and discretionary rates.
(ii) Would your best estimate assumptions differ between guaranteed rates and discretionary rates?

Answer:

(i) The names suggest that guaranteed premium rates must be continued to be offered by the company without change whereas discretionary rates can be altered. The following is discussed in detail in the Product Development subject.

There are various approaches to providing rate guarantees. At one extreme, rates can be fully guaranteed, and rates cannot be increased, irrespective of the situation. At the other extreme, rates could be varied at the complete discretion of the company. Fully guaranteed premium rates cannot be increased, even where pricing assumptions prove much worse than expected. Pricing assumptions include claims costs, expenses or rates of investment earnings which, for many products, have a significant impact on pricing. Completely discretionary rates may be changed at any time, for instance, if the circumstances of the insured changes. An example would be a rate increase for an individual on diagnosis of heart disease.
An example of guarantees falling In between these two extremes, is where rates can be altered based the experience of the whole series, and the change cannot be applied to just a few individuals but must apply to the entire cohort of policy owners. This approach is more common with guaranteed renewable term insurance. Life insurance regulations in Australia, and many other jurisdictions, place restrictions on the amount of discretion that life companies can have in their policies.

(ii) In setting valuation assumptions, the actuary needs to consider the cost of premium guarantees. As discussed under stochastic valuation methods, guarantees have an expected cost that may not be adequately captured in a deterministic model. One approach in a deterministic model is to use assumed claims rates that are higher for policies with guaranteed premium rates, than for those without, all other things equal. Implicitly, the higher assumed claims rates include an estimated cost of providing the guarantee.

Exercise 5.20:

Show that the realistic retrospective reserve agrees with the realistic prospective reserve.

Answer:

Cash flows from spreadsheet								
Year	Premium	Comm	Expenses	Death	Surr	Maturity	Retrospecive reserve (up to year 4)	Prospective BE from spreadhseet
	boy	boy	boy	eoy	eoy	eoy	(opening_res+prem-comm-expesnes)*(1.03) -death	
0								
1	583.96	(116.79)	(70.00)	(428.40)	0.00	0.00	(19.32)	(19.31)
2	558.15	(111.63)	(61.53)	(409.46)	0.00	0.00	(32.83)	(32.82)
3	537.15	(107.43)	(55.17)	(394.06)	0.00	0.00	(42.08)	(42.08)
4	531.10	(106.22)	(50.58)	(389.62)	0.00	0.00	(47.44)	(47.44)

Exercise 5.21:

Open disability income claims at the valuation date may also be valued using case estimates provided by claims managers and other experts. What might be the advantages and disadvantages of using case estimates over actuarial estimates and in what circumstances would you consider their use.

Answer:

Advantages:

- Case estimates may readily incorporate known facts about a claim or the circumstances of the case that may not be reflected in an actuarial statistical basis
- For a claim (or liability) that is large relative to the rest of the portfolio, it may be more appropriate to place more importance on individual assessment

Disadvantages:

- Estimates may lack rigorous statistical basis
- Claims manager may have financial motivation to lower reported costs and understate estimate
- May lead to inconsistency in treatment of identical claims
- May be quite subjective and change frequently depending on views of relevant manager at the time
- The statistical or actuarial basis is valid when applied to the entire portfolio, if some claims are singled out for separate treatment, this may undermine the validity of using "average" rates for the remainder.

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