Actuaries Institute Australia

LIFE INSURANCE AND RETIREMENT VALUATION

MODULE 12: ANALYSIS OF SURPLUS

Education Program
ACTUARIES INSTITUTE

Education that Counts

Fellowship Program

Module 12

ANALYSIS OF SURPLUS

Education that Counts

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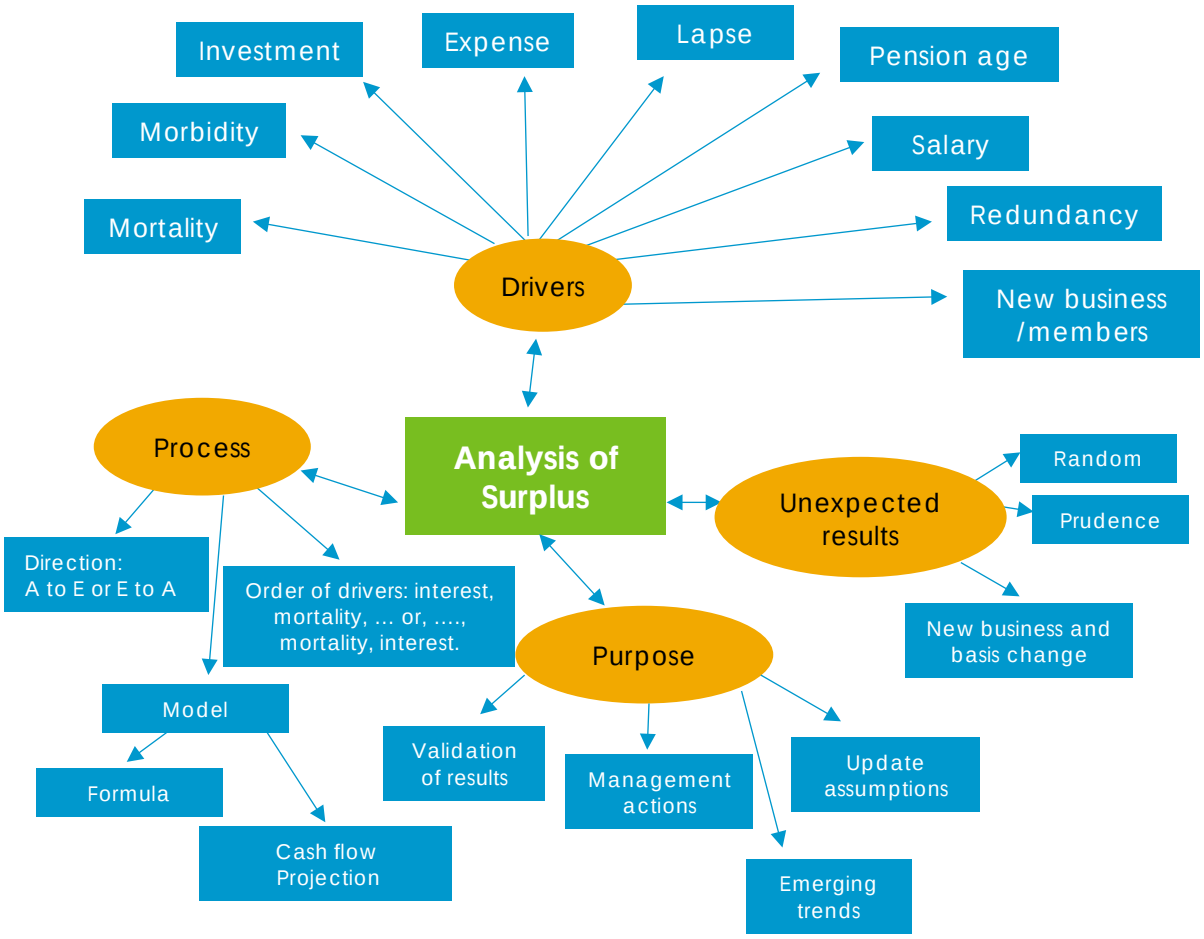
12. Analysis of surplus

The learning objectives covered in this module are:

Item	Unit/Key Performance Objective/Learning Objective
5.	**Design a process to determine the sources of surplus**
5.1.	**Explain why an analysis of surplus may be undertaken**
5.2.	**Assess methodologies for the analysis of surplus**
5.3.	**Evaluate an analysis of surplus arising**
5.4.	**Communicate outputs of the process**

Figure 12.1 provides a high-level overview of the content of this module. A good exercise is to consider what you think may be the detail behind the diagram before you read the module. Try to use first principles on how you would analyse actual valuation results compared with expected ones. Remember to think about cash flows and liabilities.

Figure 12.1: Module overview



12.1. Overview and purpose

12.1.1. Overview of the analysis of surplus

A key role of a life insurance or retirement actuary is to analyse and report on the actual experience which emerges over time for groups of policies or retirement funds. An analysis of surplus is a process that aims to explain the difference between actual experience and a valuation or other expectation. The report, or output, includes a discussion of the drivers of those differences and possible actions required or areas needing further investigation. The analysis of surplus process forms part of the monitoring stage of the control cycle.

In this module, *surplus* is defined as the excess of assets over policy or benefit liabilities at a point in time. It can be a negative amount, that is, insufficient assets to cover liabilities. The change in surplus over one year is captured in a simple formula:

(12.1) $$(A_1 - V_1) - (A_0 - V_0),$$

which can also be expressed as the change in asset values less the change in liability values:

(12.2) $$(A_1 - A_0) - (V_1 - V_0).$$

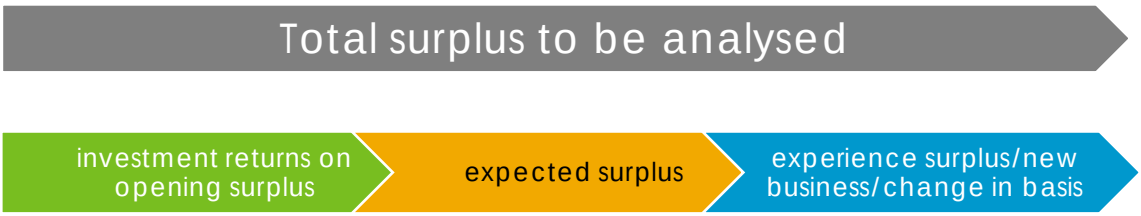
In the formulae, A_0 and A_1 are the respective asset values at the start and end of year, and V_0 and V_1 are the respective liability values at the start and end of year. The change in surplus is the surplus arising over the year. It is common for life companies to monitor over a one-year period and the rest of this module, until Section 12.4 on defined benefits, assumes a maximum of a one-year period. Section 12.4 will discuss a straightforward extension for defined benefit funds which are often examined in detail every three years.

Objective 5.3 refers to an "analysis of surplus arising", which is a better description of the purpose of this module, but standard actuarial convention labels the process an "analysis of surplus". We will use this convention throughout the rest of the module.

The analysis of surplus is a systematic approach to attributing the total result calculated in Equation 12.1 into the drivers that caused the surplus to arise. The granularity should assist in obtaining an understanding of the differences between what occurred and what was expected.

Figure 12.2 shows how the surplus arising over the period may be split into three components.

Figure 12.2: Components of surplus



A summary of the components that cause, or drive, changes in surplus is:

- returns on the original surplus;
- expected surplus, driven by deliberate prudence in the valuation basis or method (e.g. explicit allowance for future profits);
- random fluctuations that impact cash flows but not the valuation basis; and
- other unexpected changes in experience, including new business and changes in end-year assumptions.

Theoretically, the sum of the components should equal the total surplus. If the analysis is complete, any residual should be small. A small residual indicates, but does not prove, that all experience items of variation have been adequately explained by the analysis.

Investment returns on opening surplus

The opening surplus, $A_0 - V_0$, tells us nothing about how we expect V_0 (or A_0 for that matter) to change over the investigation period. However, it is clear the investment return on the opening surplus will form part of the total surplus at the end of the period.

Expected Surplus

If the valuation basis is conservative or includes an explicit allowance for future profits, there are in-built margins relative to a best estimate basis. A surplus will arise naturally as these margins are released.

Experience surplus

Due to the uncertainty involved in valuing future unknown cash flows, actual experience will never turn out to be exactly as expected. Whilst experience profit or variations are contingent on contract types, typical items which drive surplus arising for life companies are:

- investment returns;
- mortality;
- morbidity;
- expenses;
- commission;
- voluntary withdrawals;
- fees from unit-linked business; and
- new business.

Items relevant to defined benefit funds are outlined in Section 12.4.

New business

If the opening valuation only considers contracts in existence as at the opening valuation date, then new business (or new members for retirement funds) is an unexpected item in the surplus arising.

Change in basis

If experience over the period is different to expected (it is never *exactly* as expected), the valuation basis may change to reflect this. The opening basis can't anticipate a change in basis at the end of the period. If the end period basis is changed, this contributes to another unexpected surplus. The end year valuation on a new basis less its value on the opening basis capitalises the effect of the change in assumptions. This is analysed as a component of the total surplus arising.

Methodology

There are two approaches to completing an analysis of surplus. One approach, described in Section 12.3, is a cash flow projection method (also known as a *step-through approach*). The other approach described in Section 12.2, is via formulae. The cash flow approach should seem intuitive as its description is purely algorithmic and it is reasonably clear to see what is happening in each step. The formula approach will appear complicated as it requires a detailed understanding of valuation methods and approximations that are either hidden or not necessary in the full cash flow model. Some approaches may use a combination of both – with some elements calculated through a cash flow projection model and other components estimated using formulas.

Both methods involve moving systematically from expected to actual experience and assumptions, or vice versa. An actuary may choose to move from expected to actual, analysing one item at a time. Once analysed, the item moves from its expected value to its actual value in all subsequent steps of the analysis. It is also permissible to move in the other direction—actual to expected. Under this approach, each item, once analysed, is replaced by its expected value in the subsequent steps of the analysis. This may be summarised as:

- choose a direction (expected-to-actual or actual-to-expected); and
- choose the order of items to be analysed.

For example, when analysing the surplus from a group of lifetime annuity policies, the key experience items are longevity, investment and renewal expenses. The analysis could start by considering what the end-year position would have been if experience had been in line with expectations, and then change one item at a time to reflect the actual experience over the year. One possible order of allocating surplus arising is shown in Table 12.1. In this table, **yellow** cells indicate the use of the **expected experience** and **green** cells indicate the use of the **actual experience**.

Table 12.1: Example ordering of items under an analysis of surplus

Item	Expected surplus	Longevity experience	Investment experience	Expense experience (actual surplus)
Longevity	E	A	A	A
Investment	E	E	A	A
Renewal Expenses	E	E	E	A

Note that at each step, previously analysed items have been replaced with their actual values. The final position represents the actual position, provided two items are ignored.

Exercise 12.1

What two items have been ignored?

It is important to realise that there is no correct way to undertake the analysis. The allocation of the total surplus arising to various items is a matter of choice, as both the direction and order affect the amount of surplus arising that is allocated to each component. Choosing a different direction or order of analysis will change the amount attributable to each item. However, once a direction and order are chosen, it does not make sense to change the direction or order during an analysis. Whilst the direction and order may be changed each time an analysis is undertaken, it is desirable to use a consistent direction and order for future analyses so that like-with-like comparisons can be made between items over time. This helps in an analysis of trends occurring over time.

As stated above, the analysis involves replacing items with either their actual or expected value (depending on the direction chosen for the analysis). Once an item has been changed, it cannot be changed back to its original value throughout the remaining analysis. Thus, it is essential to keep track of which items have been changed as the analysis progresses. It is relatively easy to adhere to this rule with the projection approach described in Section 12.3. It is more difficult to keep track with the formula approach and this is a common cause of error in analyses of surplus.

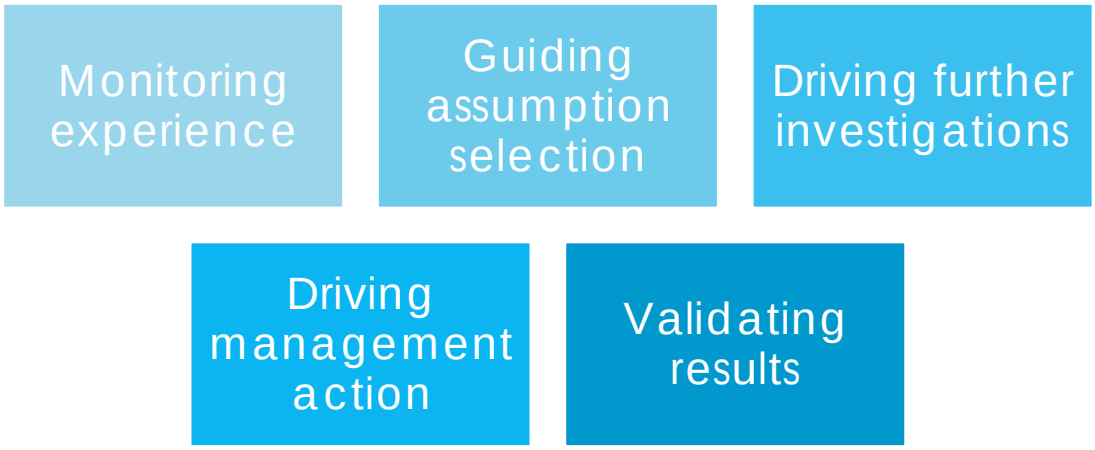
Both approaches presented in this module focus on how to analyse the direct impact of experience on cash flows (i.e. the extent to which claims, premiums, lapses, investment earnings and expenses in the year of analysis are different to expected). The examples given assume that, despite these changes in experience, the year end valuation basis is unchanged. If the valuation basis does change at the end of the year, a similar process can be applied to determine the drivers of the basis change. This involves stepping through each assumption change in isolation (again, moving either from actual-to-expected or expected-to-actual) and evaluating the resulting change in the year end liability.

As per the valuation and assumption setting processes, it is usual to conduct the analysis of surplus using broad groupings of similar products. Often, the ledger and accounting systems maintain results with sufficient detail to support analysis and reporting at a meaningful product group level. Where this is not the case, an allocation of required ledger items may be required for the analysis.

A detailed analysis of surplus by source will normally be carried out at year end for a life company (or at the end of every three years for a retirement fund). At other times during the year, the ability to carry out a detailed investigation will depend on the availability of data from the management information systems. Some of the necessary information may need to be estimated if an interim analysis is carried out. To avoid surprises, companies will generally complete the analysis monthly or at least quarterly, using approximations. Many companies perform a monthly analysis against budget. Most companies update their forecasts of full year profit as the year progresses.

12.1.2. Rationale for the analysis

An analysis of surplus can be undertaken for a range of purposes including:



A good analysis of surplus will tell a story to its audience about what has been happening across many aspects of the business by explaining the most significant business drivers of the company or fund's financial outcomes.

As part of the control cycle, insurance companies and retirement funds monitor the experience emerging for products and funds and the implications this has for liability valuation and pricing. The analysis of surplus provides a feedback mechanism to indicate which assumptions might need reviewing. It also highlights the sensitivity of the valuation to emerging experience, including the effect of new business on surplus. This, in turn, may lead to product repricing for some products or adjustment to funding rates for specific classes of membership for defined benefit funds. For example, if a life insurance analysis of surplus shows significant lapse experience losses, this may indicate the need for a thorough investigation of lapse experience by various rating factors (distribution channel, benefit type, policy size, etc.) which, in turn, may feed into a revision of the premium rates, charges and commissions.

The analysis of surplus may also suggest other management actions that could be taken. By understanding the drivers of results, actuaries can advise management on the factors affecting profit or surplus. Actuaries will also ideally play a role in advising management of actions that may be needed to address adverse experience before it becomes permanent or worsens. In an analysis where the liability assumptions used are not best estimates, the results require more careful interpretation, but the results and trends can still drive business strategies. In the example given above with significant lapse losses emerging, the thorough investigation of lapse experience may lead to improved customer service initiatives in an attempt to retain policy owners.

Analyses of surplus may also uncover areas contributing to volatility in results which could be addressed. For example, if claims experience is adversely affected by a few large insurance claims, the life company might consider reducing its retentions and making more use of reinsurance. Similarly, a defined benefit fund may make greater use of external insurance for death benefits. Volatility in investment experience could be addressed through better matching of assets and liabilities or the use of derivatives, subject to any legal restrictions. Often, the initial results from the analysis of surplus may lead to deeper analysis requiring additional data at a more granular level. It can also lead to discussions with the business – particularly claims management teams – around insights that can contribute to understanding the analysis results.

The analysis of surplus also provides a semi-independent check on the accuracy of the valuation and of the data in the company or fund's accounts. It does this by ensuring that all material changes in the valuation result are explained by underlying drivers of change. Where a change is unable to be explained, it may indicate a source of error in the valuation requiring further investigation. Examples of errors which may be uncovered in an analysis of surplus include:

- administrative errors in recording certain policy changes, resulting in incorrect recording of lapses. Unexplained lapse losses may give rise to further investigations leading to the discovery of such errors;
- errors in the approach taken to modelling the business – either in the coding of the projection or in any modelling methodology assumptions;

- premiums that have been recorded correctly in the policy administration system and valuation of liabilities, but double-counted in the accounting system; and
- failure to reverse a manual provision for contributions tax liability after annual contributions tax processing has occurred.

Conducting an analysis of surplus and explaining the result with an acceptable residual is often a requirement of internal reviews and external audits. Thus, the process for conducting these analyses needs to be robust enough for the business and valuation concerned that it will deliver a result within the often tight financial reporting periods.

Thus, the analysis of surplus is an important management tool in the monitoring and successful operation of a life company.

12.1.3. Limitations on uses of the analysis of surplus

The analysis is not a complete check on the sources of variance as:

- some items of experience may be estimated based on the valuation results themselves, leading to a loss of independence in the analysis;
- it may not be possible to explain all experience items, although a typical aim is for the unexplained surplus arising to be lower than company-specified limits;
- the analysis is not very sensitive to small errors, which can accumulate to a material misstatement over time; and
- the analysis does not provide a foolproof verification that the valuation data is correct. For example, consistently wrong policy or member data over time may not be identified through an analysis of surplus.

The analysis of surplus for a single period is not an ideal indicator of the financial performance of a life insurance company and some experience variances may give misleading signals.

For example, higher than expected lapse rates for a level premium term insurance will result in experience profits if a conservative policy liability is greater than zero, as there is usually no surrender value for this type of policy. However, if the best estimate liability is less than zero, the loss of future profit margins may exceed the one-off experience profit and the company could actually be worse off. In addition, if the higher than expected lapse rates are a sign of dissatisfied policy owners who are moving their business to a competitor, this may actually signal lower future new business and lower future levels of profit for the company. An embedded value analysis can give a better measure of financial performance. This topic is discussed in Module 15 (Appraisal values).

Approximate methods may be necessary to check on the analysis of surplus model. For example, commission could be modelled approximately, serving as a check on the commission item in the analysis of surplus model. Further, analysing commission in detail can identify if there have been errors in payments.

12.1.4. How surplus arises

When actual experience aligns with expected experience, there is a symmetry between the movement in the value of assets and the value of liabilities. One way to view this is to consider the formula for the progression of reserves from one period to the next. Module 5 (Life valuation) verbally explained the formula linking net premium prospective reserves for some time t, say, to time $t + 1$. The formula below is the gross premium equivalent showing the progression of reserves, ${}_tV_x$, over the t^{th} policy year for a group of lives aged x at commencement of a non-participating annual premium whole of life insurance policy.

(12.3) $$({}_tV_x + P - E)(1+i) = B\, q_{x+t} + {}_{t+1}V_x\, p_{x+t},$$

where P represents the premium payable; i is the valuation rate of interest; E represents expenses assumed to be incurred at the start of a policy year; and B is the benefit payable on death.

Formula 12.3 demonstrates that when interest is added to the sum of the reserve at the start of the period together with premiums due less expenses payable, then expected claims in the year can be paid together with enough assets left over to set up the reserve for the survivors. This balance only holds true when actual experience is in line with the valuation assumptions.

It helps to consider how the balance sheet changes through the year in the situation where experience matches assumptions. Unless stated otherwise, we always use the concept of pooling to start with a policy owner and "allow" a fraction of that policy owner to "die". What we really mean is that we have *n* similar lives and a fraction of that cohort die, lapse, etc.

Starting with the liability for a particular type of contract and a policy owner:

- there is a liability equal to ${}_tV_x$ at the start of year *t* (in respect of *n* identical policy owners who hold identical contracts but our convention is to normalise *n* = 1);
- a reserve of assets equal to ${}_tV_x$ are held on the asset side of the balance sheet;
- the policy owner pays a total premium *P* just after time *t* and total expenses of *E* are incurred;
- there is an implicit assumption that if $E > P$, then there are other assets on the balance sheet to cover the shortfall;
- any claims may occur on average at mid-year and the simplified formula assumes they are paid at the end of the year;
- there will be q_{x+t} claims with a total claim amount of $B\ q_{x+t}$;
- assets fall by $B\ q_{x+t}$ when the claim is paid and the liability of $B\ q_{x+t}$ in respect of q_{x+t} lives is released;
- liabilities equal to ${}_{t+1}V_x$ are required at time $t+1$ for the remaining $(1 - q_{x+t})$ policy owners and this is equal to the original assets, adjusted by cash flows and investment returns.

In reality, actual cash flows, including changes in the values of assets, will differ from expected. Thus, assets at the end of the year will be different than ${}_{t+1}V_x\ p_{x+t}$, and a surplus or deficit arises. If, for example, actual expenses were *R*, but all other items were as expected, then the assets at the end would be ${}_{t+1}V_x\ p_{x+t} - (R - E)(1 + i)$.

The valuation basis may be more complex than the simple example above and include items such as a planned profit margin and taxation. The planned profit margin is treated in the same way as an expense in the above formula. Similarly, taxation may be treated as an expense, although the relevant tax rules may give rise to further modelling complexities.

In the discussion above, it was assumed that assets and liabilities are equal at the start of the period. In practice, life companies have assets in excess of liabilities, such as solvency capital. Retirement funds may have funding surpluses or deficits. These excess assets, or possible deficits, are analysed first as "unexpected" items and then the analysis proceeds according to the selected methodology.

12.1.5. Choosing drivers of change

The required breakdown of an analysis will be different for different product types as the key business drivers, and their impact, will be different. These drivers may be deduced from the contract definitions. The ability to articulate the key drivers from contract definitions is a key actuarial skill. For example, the following list highlights the key drivers for three common contracts.

- claims and lapse rates will be major sources of surplus variance for term insurance;
- investment returns affects asset-based fees for unit-linked business; and
- mortality and investment returns will be the major sources of surplus variance for guaranteed lifetime annuities.

Exercise 12.2

(i) What are the major sources of surplus for the following contracts: group income protection, variable annuity, and participating endowment insurance?

(ii) Explain why investment returns are not a key driver for term insurance.

12.2. Formula-based approach

This section describes the formula-based approach to conducting an analysis of surplus. It derives formulae for a broad variety of conventional insurance contracts. The formulae are an amended version of those presented in Ranson's 1987 monograph *Financial Aspects and the Valuation of Long Term Business Funds*.

It is important to understand the reasoning behind the development of the formulae rather than attempting to memorise them. The formulae may appear to be complicated as they require an understanding of a number of key actuarial topics that were developed in the Foundation program. They also require a good understanding of the concepts in Module 5 (Life valuation).

In professional practice, the analysis of surplus will usually be completed using cash flow models, as described in Section 12.3. The actuary needs to understand what the model is doing and why it is suitable. The thought processes in this section may be applied when designing and building a cash flow model. Another reason for learning how to develop formulae is that they may be used as an approximation to check on the output of a cash flow model.

The direction in the derivation of the formulae is from **actual-to-expected**. The order that items are analysed are:

- interest surplus;
- expense and bonus surplus (sometimes referred to as *loading surplus*);
- mortality and miscellaneous surplus split into:
  - mortality;
  - surrender; and
  - new business; and
- cost of basis change.

Section 12.1.1 introduced the following formula to measure the surplus arising in a year:

$$Surplus\ arising\ in\ year\ =\ (A_1 - V_1) - (A_0 - V_0) = (A_1 - A_0) - (V_1 - V_0).$$

The analysis of surplus using a formula approach requires liabilities to be calculated on the same basis. For ease of notation, assume the liabilities in Expression 12.1 (i.e. V_0 and V_1) are on the same basis. If the year-end basis is different to the start of year basis, then subtract V_1 from the end-year liability V'_1, say. The difference, $V'_1 - V_1$, is **the cost of basis change.**

A revenue account for the year, ignoring taxation, is shown in Table 12.2.

Table 12.2: Revenue account

Revenue Account	
Start of year assets	A_0
Premiums received	P
Interest	I
Claims	C
Expenses (internal and external costs)	E
End of year assets	$A_1 = A_0 + P + I - C - E$

The following sections consider how each experience item impacts this revenue account and how to use formulae to measure this impact.

12.2.1. Interest surplus

Remember that we have chosen to move from actual to expected.

We start with the actual interest, I, shown in the revenue account. The actual interest, I, includes interest on the surplus at the start of the year, $A_0 - V_0$, as well as actual interest on the reserves backing the opening liability, V_0.

The problem to be solved in this section is how to estimate the expected interest.

If we assume premiums, claims and expenses are received or paid continually throughout the year, then we may use the approximation that they occur, on average, mid-year. This is a restatement of Formula 12.3, which assumed premiums and expenses occur at the start of the year and claims occur at the end of the year.

The expected interest, i, is the expected interest on reserves backing the opening valuation liability, V_0, plus expected interest for one-half of a year on the actual cash flow, $P - C - E$, assumed to occur mid-year.

If actual interest exceeds expected interest, then a surplus will arise. Thus, the interest surplus is the difference between actual interest and expected interest:

(12.4) $$Interest\ surplus = I - iV_0 - \frac{1}{2}i(P - E - C).$$

12.2.2. Expense surplus

The problem to be solved in this section is how to estimate the expected expenses. Technically, this section includes bonus surplus for with-profit contracts valued using a net premium method. That explains why this surplus item is sometimes referred to as *loading surplus* in other literature.

We now use expected interest as we calculated interest surplus in the last section, and we are moving from actual to expected.

The revenue account records the actual premiums and expenses (including commission). We assume the revenue account expense item, E, may be split into:

- renewal expenses relating to business in-force throughout the year, $E^{renewal}$; and
- initial expenses relating to new business, E^{new}.

The start of year valuation included an allowance for renewal expenses. If the renewal expense allowance exceeds actual expenses, then a surplus will arise. The allowance for renewal expenses depends on the valuation method, and we discuss gross and net premium valuations separately.

Gross premium valuation

A variety of methods are possible for the expense component in gross premium valuations. The simplest is where the allowance for expenses is a proportion of the office premium, k_1P, say. Some companies may also include a fixed cost allowance per contract, $k_2 N$, say, where N is the number of contracts at the relevant valuation date.

We're assuming cash flows occur mid-year and, hence, a suitable metric for the number of contracts is the average number of contracts in force through the year. As above, the surplus arising is measured at the end of the year. Half a year's interest, at the expected rate, on the mid-year cash flow is therefore required. A formula for the expense surplus is:

(12.5) $$Expense\ surplus\ (gross\ premium\ method) = (k_1 P + k_2 N - E^{renewal})(1 + \frac{i}{2})$$

Net premium valuation

In the net premium valuation method, the expense allowance is the difference between the office premiums (i.e. the actual premiums charged) and the corresponding net premiums, as explained in Module 5 (Life valuation), Section 5.2.3. Assuming the valuation net premiums (*NP*) that correspond with the office premiums (*P*) are also payable, on average, mid-year, then the expense and bonus loading surplus is:

(12.6) $$Expense\ surplus\ (net\ premium\ method) = (P - NP - E^{renewal})\left(1 + \frac{i}{2}\right)$$

For participating contracts, the difference between *P* and *NP* may also be used to pay for bonuses. The surplus analysed is really the loading for expense and bonuses but bonuses are often ignored in practice.

The net premiums are an artificial construct and not actually received. The total of net premiums in-force at the beginning and end of the year will be known, but these totals do not necessarily correspond with the gross premium receivable throughout the year.

The formula above requires us to estimate net premiums in-force in the middle of the year. To estimate this value, the beginning and end of year net premiums in-force could be averaged. Alternatively, net premiums as a proportion of gross premiums could be estimated using the ratio of net to gross premiums at the year-end valuation.

The formula above for expense surplus may be written for any method as:

(12.7) $$Expense\ surplus\ (any\ method) = (P - VPN - E^{renewal})\left(1 + \frac{i}{2}\right)$$

where *VPN* represents the valuation premium net of renewal expenses.

For a net premium method, *VPN* represents the net premium. For a gross premium valuation, it represents the office premium less the allowance for renewal expenses. In subsequent sections, we will work with *VPN* as we have now analysed renewal expenses.

12.2.3. Mortality and miscellaneous surplus

We have now attributed explanations of the surplus arising from interest and renewal expenses. The balance of the surplus arising is, therefore, the actual surplus arising ($A_1 - A_0 - V_1 + V_0$) less each of the components of surplus already attributed to interest and expenses. This can be expressed as:

$$Mortality\ \&\ misc.surplus = A_1 - A_0 - V_1 + V_0 - I + iV_0 + \frac{1}{2}i(P - E - C) - (P - VPN - E^{renewal})\left(1 + \frac{i}{2}\right)$$

(12.8)
$$= V_0(1+i) + (VPN - C - E^{new})\left(1 + \frac{i}{2}\right) - V_1,$$

where we have used the revenue account, $A_1 - A_0 - I = P - E - C$.

The next few sections break down Expression 12.8 into its constituent parts of mortality, surrenders and new business.

We assume that there is sufficient information to split the revenue claim item, *C*, into actual death claims, C^d, and actual surrender claims, C^s.

12.2.4. Mortality surplus

The topic of mortality surplus was introduced in the Foundation subjects and we can use Equation 12.3 to summarise what was presented in that subject. We are now using expected interest and expected expenses. We are attempting to determine a method to calculate the expected death claims.

Rewriting equation 12.3, we have:

(12.9)
$$({}_tV_x + P - E)(1+i) = q_{x+t}(B - {}_{t+1}V_x) + {}_{t+1}V_x.$$

In the Foundation subjects, the expression $q_{x+t}(B - {}_{t+1}V_x)$ was labelled the *death strain at risk*, or the *expected death strain*. That formula is appropriate for a contract that either remains in force at the end of the year or exits through death. For contracts that leave through withdrawal or arrive as new business, the expression should be multiplied by 0.5. You may want to revise your exposed-to-risk notes from subject CT4 or the new Foundation subject CS2.

The actual death strain (as specified in the Foundation subjects) is the actual claims paid out less the end year reserves in respect of those contracts. Assuming death claims are paid mid-year, the actual death strain is the payments made on death, C^d, inflated to the end of the year less the end-year valuation reserve in respect of contracts that exited through death (V_1^d). An expression for the actual death strain is, therefore:

(12.10) $$Actual\ death\ strain = C^d(1 + \tfrac{i}{2}) - V_1^d$$

A significant assumption in the above death strain expressions is that premiums are payable immediately after the valuation date. A consequence is that expected valuation premiums and actual premiums received in respect of contracts that exited through death are identical. In practice, some policyholders who died during the year will have paid their premium before their death, whereas others may die before paying their premium. The difference between expected valuation premiums and actual valuation premiums therefore needs to be considered.

Equation 12.3 assumes that premiums and expenses are payable at the start of the year and benefits are payable at the end of the year, so actual valuation premiums are unaffected by actual deaths throughout the year. Since it is likely that actual deaths will differ from expected deaths, premiums received will be different to anticipated.

Actual valuation premiums received, net of renewal expenses, are *VPN – DP*. *DP* represents valuation premiums, net of renewal expenses, not received because the policy owners died before paying them.

Expected valuation premiums, net of renewal expenses, in respect of contracts in force at the end of the year and those who exit through death, are $VPN - 0.5q_xVPN$. This assumes an even spread of deaths throughout the year and the valuation premiums are due mid-year (i.e. half the deaths will occur before premiums are paid mid-year and half will occur after premiums are paid mid-year). Expected premiums for new contracts or those exiting through withdrawal are $VPN - 0.25q_xVPN$.

If there are more death payouts than expected, then there is a strain (remember these formulae are based on a whole of life insurance policy, under which the sooner a death occurs, the less profitable the business is). The opposite is true when death payouts are less than expected. Similarly, receiving more premiums than expected is a positive outcome. Hence, the mortality surplus is defined as the sum of:

- expected death strain less actual death strain; plus
- actual valuation premiums less expected valuation premiums.

Actual less expected valuation premiums can be represented by:

(12.11) $$\sum(\alpha\, q_xVPN - DP)(1+\tfrac{i}{2})$$

where $\alpha = 0.5$ for contracts in force at the end of the year and those who exited through death, and 0.25 otherwise.

12.2.5. Surrender surplus

Policy owners have the right to stop paying premiums at any time. The possible consequences to the life company are threefold:

- the contract ceases with zero value;
- the contract ceases and a payment is made via;
  - cash payment to the policy owner; or
  - cash transfer to another provider, which is typical for retirement funds; or
- the contract continues as a 'paid-up' contract.

The 'paid-up' possibility is an example of a policy alteration and is not discussed further in this subject.

This section discusses the situation where the contract ceases and measures the effect on the surplus arising. Normally, surrender values are less than the corresponding valuation reserves and a surplus will arise on surrender.

We have now analysed interest, renewal expenses and mortality and, thus, all three are now calculated using the (expected) valuation basis. The amount of actual surrenders, C^s, is known from the revenue account and the problem in this section is to determine an expression for the expected amount of surrenders.

Assets were held at the start of the year in respect of the withdrawing contracts, V_0^S. Valuation premiums, VPN^{surr}, net of renewal expenses, are assumed to have been received mid-year. It may seem odd, but our approach also assumes surrenders occur mid-year.

In the mortality section, expected surrenders were included in the expected death strain and expected valuation premiums lost through death. We can label that component of the death strain and lost premiums as EDS^{surr}. Since we have already allowed for EDS^{surr} it should be subtracted from the calculation of surrender surplus.

The surplus arising due to surrenders may be written as:

(12.12) $$V_0^S(1+\mathrm{i}) + (VPN^{\text{surr}} - C^s)(1+\tfrac{i}{2}) - EDS^{\text{surr}}$$

12.2.6. New business surplus

New business is unanticipated when analysing surplus arising, as the start of year valuation does not consider future contracts.

Initial expenses are proportionally much larger (often said to be *heavier*) than renewal expenses. We have assumed that the revenue account can identify initial expenses, which includes initial commission. In this section, we refer to actual initial expenses that relate to new business sales as E^{new}.

By analogy to Equation 12.3, the valuation premium, net of renewal expenses, needs to cover the reserve at the end of the period and any expected death strain, EDS^{NB}. The latter has already been included in the mortality section and therefore needs to be subtracted from the new business surplus calculation.

The initial expenses are likely to cause a new business strain.

The formula for the surplus arising from new business is:

(12.13) $$(VPN^{NB} - E^{\text{new}})\left(1 + \frac{i}{2}\right) - V_1^{NB} - EDS^{NB}.$$

12.2.7. Combining the components

It is shown in the appendix that the sum of the individual components equals the total surplus. It is a tedious exercise in algebra to show equivalence and this will not be tested in an examination.

As explained at the start of this section, the point of working through the formula approach to an analysis of surplus is NOT to ensure that you are able to memorise and deduce each of the formulae presented. Instead, the benefit in working through each of the formulae above is for you to think about how individual components of experience impact the total surplus arising.

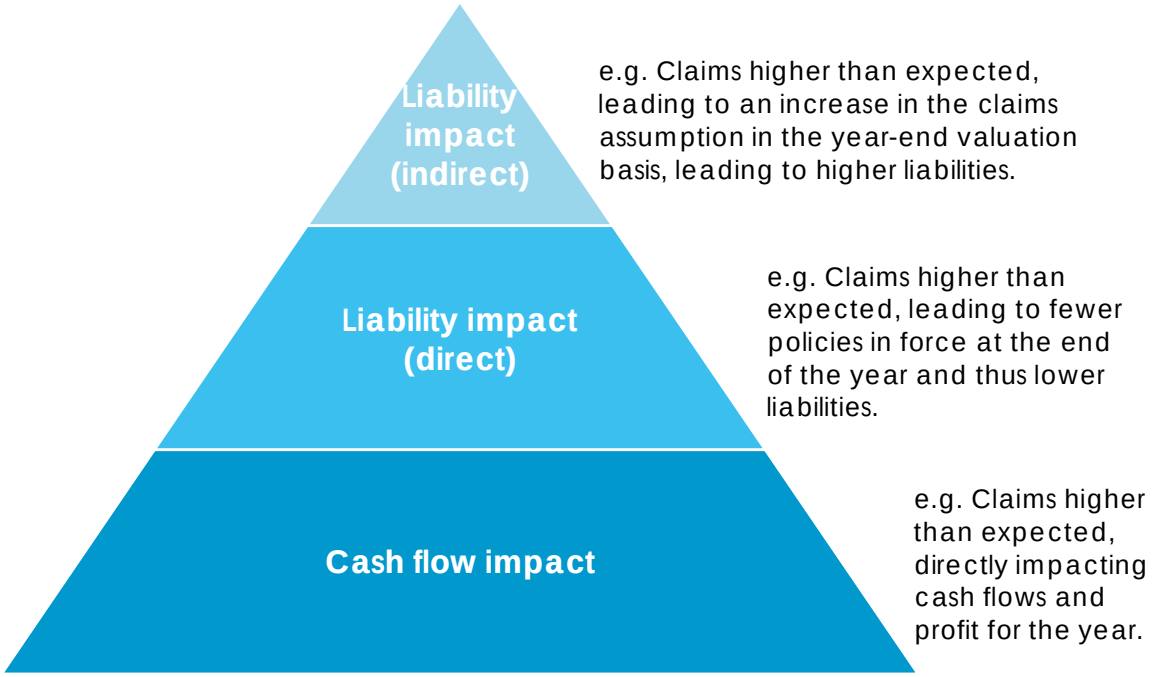
This should help your understanding of the step-through approach presented in Section 12.3.

12.3. Step-through approach

The step-through approach involves using a cash flow projection model. The cash flow model may use either data at an individual policy level or grouped data.

The step-through approach is conducted by systematically stepping though the impact of each experience item, as highlighted by the example in Table 12.1. The impact of most experience items can be considered as either a cash flow impact, a direct liability impact or an indirect liability impact, as summarised in Figure 12.3.

Figure 12.3: Step-through approach components



Companies generally develop sophisticated models to support the valuation and business planning process. Results from these models include projected cash flows, liability values and profits. They may also include estimates of solvency capital amounts and even embedded values at future points. These models may also include expected future new business. Results are generally produced at a product grouping level that combines similar products to provide a meaningful and practical view to management. These models may be used to perform the step-through analysis.

The step-through process involves the recalculation of modelled cash flows and liabilities, altering the inputs or assumptions for one experience item at a time. By the time the final experience item is incorporated, modelled results will closely replicate actual results (assuming we're working in an expected-to-actual direction) and any residual differences should be small.

There are different ways to perform the calculation and we have highlighted one way to analyse a life insurance risk product in Table 12.3. This example does not include a step to allow for new business. It examines the surplus arising from a block of business in force at the start of a year and how it changes over the year.

Table 12.3: Step-through approach – process flow

Surplus components	1. Expected surplus	2. Investment income	3. Claims	4. Expenses	5. Lapses	6. Change in basis	7. Actual surplus
Premiums	Expected	Expected	Expected	Expected	Adjusted	Actual	Actual
Investment return	Expected	**Actual**	Actual	Actual	Actual	Actual	Actual
Claims	Expected	Expected	**Actual**	Actual	Actual	Actual	Actual
Expenses	Expected	Expected	Expected	**Actual**	Actual	Actual	Actual
Lapses	Expected	Expected	Expected	Expected	**Actual**	Actual	Actual
End Year Liability	Expected	Expected end year portfolio	Allow for actual claims	As per Step 3	Step 3 plus allow for actual lapses	**Actual surviving policies on revised basis**	Actual surviving policies on revised basis
Surplus Arising	Expected	Adjusted	Adjusted	Adjusted	Adjusted	Actual	Actual
Difference in Surplus		Impact of Economic Returns	Impact of Actual Claims	Impact of Actual Expenses	Impact of Actual Lapses	Impact of New Basis	Residual Impact

The step-through approach is seeking to explain the surplus arising; i.e. $(A_1 - A_0) - (V_1 - V_0)$, which is equivalent to $(P + I - E - C) - (V_1 - V_0)$.

Comments on each step are included in Table 12.4

Table 12.4: Notes on the risk insurance step-through process

Step	Notes
1. Expected surplus	All movements are on an expected basis.
2. Investment income	This step compares actual investment income and expected investment income. Sometimes, any change in the year-end discount rate is included in this step, although the approach above considers any basis change as a separate step
3. Claims	Different product types often have different impacts on the change in liability item. Usually, lump sum risk products have less of an impact than contracts that have a stream of payments, such as income protection and annuity business.
4. Expense	In Module 6 (Profit), we described how initial commission may be deferred through the liability. Thus, there may be a change in liability item relating to initial commissions.
5. Lapses	The cash flow model may be rerun using actual lapsed policies, or the effect of lapses may be calculated using approximate techniques.
6. Change in basis	It is possible that this step is repeated for each basis change to understand the impact on the end year liability for each change.
7. Actual surplus	There is likely to be a residual unexplained difference. Further analysis could be undertaken to understand whether business mix, misstatements, modelling approximations or other factors have caused a change.

It is important to point out again that the order in which items are addressed will have an impact on the attribution to individual drivers. One reason for performing the analysis is to understand trends over time and, hence, it is preferable to keep the same order each time the analysis is performed.

One-off items or abnormal items in the revenue account could be included in the analysis of surplus, as these may be significant components of surplus/profit. An example is the release of tax provisions.

As with any actuarial process, reconciliation of data and reasonableness checks of results are important. When preparing models for an analysis of surplus, validation checks should be performed against other (preferably, previously validated) reports and systems for items such as policy liabilities, numbers of policies, sums insured and premiums. For example, actual investment income and experience data for the analysis should be validated against ledger sources such as the profit and loss account.

12.3.1. Simple step-through example

Table 12.5 shows a three-year cash flow projection for a group of term life insurance policies which have been in force for a number of years. Premiums and expenses are paid at the start of the year. Benefits and surplus are paid/released at the end of the year. The amount of assets in excess of policy liabilities at the start of Year 1 is 100. Tax is ignored, and the discount rate is 5% p.a.

In this example, the order of experience analysis is:

1. claims;
2. expenses;
3. investment returns.

Different orders of analysis are equally valid but will give slightly different results.

A conservative valuation basis has been used to derive the numbers in Table 12.5. The basis used is a special type of basis that will be explained in full in the Life Insurance Application subject. Note that in this example, despite experience being different than expected, there is no consequent change to the valuation basis at the end of the year.

Since the valuation uses a conservative basis, surplus will naturally arise each year if experience is in line with best estimate assumptions. Do not confuse this "expected" surplus (when experience is in line with best estimate assumptions) with the unanticipated surplus that arises when experience is different than best estimate assumptions. The focus of an analysis of surplus is on understanding the unexpected surplus arising.

Table 12.5: Original projection

Year	Premium (start of year)	Expense (start of year)	Benefit (end of year)	Surplus arising (end of year)
1	500.00	50.00	1,100.00	110.00
2	550.00	55.00	1,210.00	121.00
3	605.00	60.50	1,331.00	133.10

Using the projection components in Table 12.5 above and the assumed 5% discount rate, the policy liability at the start of Year 1 is 2,209 and the policy liability at the end of Year 1 is 1,582, as shown in Table 12.6. Note that you won't be able to replicate the profit margins shown in Table 12.6 based on the information given.

Table 12.6: Expected change in liability using original basis

	Policy liability at the start of Year 1	Policy liability at the end of Year 1
PV benefits	3,295	2,360
+ PV expenses	+ 157	+ 112
− PV premiums	− 1,573	− 1,126
+ PV profit margins	+ 330	+ 236
= Policy liability	= 2,209	= 1,582

If experience is as expected, the Year 1 surplus of 115 is derived as in Table 12.7.

Table 12.7

	Year 1 surplus
Premiums	500
Investment income = (100 + 2,209 + 500 – 50) x 5%	138
Claims	(1,100)
Expenses	(50)
Increase in policy liability = −(1,582 – 2,209)	627
Surplus	115

(The investment income includes income from the opening surplus of 100.)

The components of the Year 1 surplus are shown in Table 12.8.

Table 12.8: Components of surplus

Investment income on assets in excess of policy liabilities = 100 x 5%	5
Expected surplus emerging	110
Total surplus	**115**

Now consider the situation where the experience in Year 1 varies from the original projection's assumptions as follows:

- investment income is 110 rather than 138;
- benefit payments are 1,000 rather than 1,100; and
- expenses are 80 rather than 50.

The analysis of surplus is completed in a step-by-step process where each of the expected components of surplus is replaced by the actual outcome.

Step 1: Actual Claims

In Table 12.9, benefit payments are 1,000 in Year 1 instead of 1,100 as assumed in the original projection. This increases the surplus to 215. Note this example is simplified as it assumes no change in the policy liability at the end of the year, even though there were fewer than expected claims. For a term insurance policy, the impact of a variation in claims experience on the end of year policy liability is small relative to the impact on claim payments. The movement in the liability would be greater for traditional policies. In practice, there will also be a movement in the policy liability due to lapses being different from expected. Lapse experience has been ignored in this example.

Table 12.9: Actual claims

	Year 1 profit
Premiums	500
Investment income	138
Actual Claims	(1,000)
Expenses	(50)
Increase in policy liability	627
Surplus	215

The components of Year 1 surplus, using actual claims, are shown in Table 12.10.

Table 12.10: Surplus attributable to claims

Investment income on assets in excess of policy liabilities = 100 x 5%	5
Expected surplus emerging	110
Claims experience surplus = 1,100 – 1,000	100
Total surplus	**215**

Step 2: Actual Expenses

Expenses are 80 instead of 50 in the original projection. This has a flow-on impact of causing expected investment income to reduce as the expenses are assumed to be paid at the beginning of the year. The overall impact is to reduce the profit to 183.5, as shown in Table 12.11.

Table 12.11: Actual claims and expenses

	Year 1 surplus
Premiums	500
Investment income (= 138 – 30 x 5%)	136.5
Actual Claims	(1,000)
Actual Expenses	(80)
Increase in policy liability	627
Surplus	183.5

Note in Table 12.11 that the expected investment earnings rate of 5% was used, as the impact of the actual investment earnings being different to expected has not yet been incorporated into the analysis.

The updated components of the Year 1 surplus are shown in Table 12.12, which now includes the surplus attributed to expense experience. Using the step-through process in Table 12.3, we could immediately state that the surplus attributable to expenses is this run's surplus less the previous surplus: 183.5 – 215 = −31.5.

Table 12.12: Surplus attributable to expenses

Investment income on assets in excess of policy liabilities = 100 x 5%	5
Expected profit margins emerging	110
Claims experience surplus = 1,100 – 1,000	100
Expense experience surplus = (50 – 80) x (1 + 5%)	(31.5)
Total surplus	**183.5**

The expense experience loss reflects the difference between the actual and expected expenses at the start of the year, accumulated at the expected rate of investment return (5%) to the end of the year.

Step 3: Actual Investment Returns

Investment income is 110, compared with 138 in the original case. The overall impact of all experience items is to reduce the surplus to 157, as shown in Table 12.13.

Table 12.13: Actual Cash Flows

	Year 1 profit
Premiums	500
Actual Investment income	110
Actual Claims	(1,000)
Actual Expenses	(80)
Increase in policy liability	627
Surplus	157

The actual rate of investment income earned is determined by solving for i in the equation: $(100 + 2{,}209 + 500 - 80) \times i = 110$. The solution to this equation is $i = 4.03\%$. The calculation of this rate allows the actual investment income to be split between excess assets and the assets backing policy liabilities. Note that this equation uses the actual rather than the expected cash flows for the year.

The components of the Year 1 surplus are shown in Table 12.14. The calculation of the investment surplus is shown in Table 12.14 but could be deduced as 157 – 183.5 = −25.5.

Table 12.14: Actual experience items

Investment income on assets in excess of policy liabilities = 100 x 4.03%	4
Expected profit margins emerging	110
Claims experience surplus = 1,100 – 1,000	100
Expense experience surplus = (50 – 80) x (1 + 5%)	(31.5)
Investment experience surplus = (2,209 + 500 − 80) x (4.03% − 5%)	(25.5)
Total surplus	157

The investment experience loss reflects the difference between the actual and expected investment return on the policy liability at the start of the year plus the actual net cash flows (premiums less expenses). Again, this example is a little artificial as it assumes no change to the policy liability at the end of the year due to changes in the discount rate. In practice, an accurate analysis will include a tracking of the movement in end of year policy liabilities from expected to actual due to lapses, deaths, changes in the discount rate and changes in other assumptions.

12.3.2. Analysis of profit example

We have used the term *profit* rather than *surplus* in this section as the example which follows is in line with Australian practice on profit reporting. This approach was outlined in the Core Actuarial Management subject (Part II Control Cycle), recapped in Module 6 (Profit), and will be considered in detail in the Life Insurance Applications subject. A brief recap is that profitable contracts would have negative best estimate liabilities[1] on the day the contract is sold. The Australian Accounting standards force companies to set the liability to zero on day one. This means that the basis is now conservative and surplus, or profit, is expected each year. The profit (0 – realistic negative liability) is released evenly over the term of the contract using a metric chosen by the company. In this example, expected profit is divided by expected premium to derive a "profit margin". This profit margin measures the expected release of surplus each year. As stated above, an analysis of surplus is designed to analyse unanticipated surplus.

The example below shows an analysis of profit for a portfolio of term insurance policies. The related calculations can be found in the spreadsheet for this module. You should review the calculations in the spreadsheet and make sure you're able to replicate them.

Investment returns on assets in excess of policy liabilities (e.g. retained earnings) are not shown here. This aligns with the step-through method, where we begin by setting assets equal to liabilities at the start of the period.

The following valuation assumptions are made:

- premium of $1,000 payable yearly in advance
- sum insured payable immediately on death
- no surrender value
- initial expenses of $1,200 per policy
- death claims of 35% of premiums in the first year, increasing by 8% p.a.
- renewal expenses of 10% of premiums in the first year, increasing by 6% p.a.
- the lapse rate is 15% p.a.
- the discount rate is 5% p.a.

[1] Remember a negative liability increases the net asset position (assets – liabilities)

- premiums and initial expenses are paid at the start of the year; claims are paid mid-year and renewal expenses are paid at the end of the year

From these assumptions, a projection of premiums, claims and expenses is calculated, as show in Table 12.15:

Table 12.15: projected cash flows

Year	Premium	Claims	Initial expenses	Renewal expenses
1	1,000	350	1,200	100
2	850	321		90
3	723	295		81
4	614	271		73
5	522	249		66
6	444	228		59
7	377	209		53
8	321	192		48
9	272	177		43
10	232	162		39

The cash flows shown in Table 12.16 are discounted to determine the best estimate liability and the present value of expected profits. For this product, premiums are used as the profit carrier or driver. The profit margin is 19.1% of premiums, being the present value of profits (882), divided by the present values of premiums (4,615).

Table 12.16: Present value of projected cash flow items

Cash flow	Present value
Premiums	4,615
Claims	(2,008)
Initial expenses	(1,200)
Renewal expenses	(526)
Expected profit	882

At the beginning of the policy, before any premiums are received or expenses incurred, the policy liability (calculated as the present value of premiums less claims, expenses and profit margins) is zero. This can be checked from the calculations given in Table 12.16 above.

The expected profit in Year 1 is calculated as the profit margin percentage applied to the premium cash flow, i.e., 1,000 x 19.1% = 191, plus interest on the profit margin of 10 (191 x 5%), totalling 200. Interest is added to profit emergence as the timing of profit emergence is at the start of the year and the expected profit is measured at the year-end.

This can be verified from the cash flow (premiums less claims and expenses) accumulated with interest to the end of the year, less the increase in the policy liability over the year; i.e., (1,000 – 1,200) x 1.05 – 350 x $\sqrt{1.05}$ – 100 – (−869 – 0) = 200. Note that 869 in this equation is the value of the policy liability at the end of the year, which is not available from the information presented above.

Let us assume that actual experience in Year 1 differs from the projection assumptions as follows:

- claims are 400 instead of 350;
- lapses are 17% instead of 15%. As a result, the closing policy liability is −849 instead of −869;
- renewal expenses are 110 instead of 100;
- the investment return equals the assumed discount rate.

The claims experience loss is the difference between the expected and actual claims, accumulated with interest to the end of the year, i.e., (350 – 400) x $\sqrt{1.05}$ = −51. The claims experience will also have a minor impact on the policy liability, as the policies remaining in force will differ from expected. However, this effect has an immaterial impact in this example and has therefore been ignored.

The lapse experience loss arises because there are fewer policies remaining in force at the end of Year 1 than expected. The lapse loss is −869 – (−849) = −20. In effect, this loss is driven by the negative policy liability and arises because the acquisition costs for the extra lapsed policies must be recognised in full, rather than continuing to be deferred. This is not an assumption change, rather, it is applying the original valuation assumptions to reduced in-force premium volumes due to higher lapse experience.

The expense experience loss is the difference between the expected and actual expenses, i.e. 100 − 110 = −10.

The actual profit in Year 1 is now 119, compared to the expected profit of 200.

This can be verified from the cash flow (premiums less claims and expenses) accumulated with interest to the end of the year, less the increase in the policy liability over the year, i.e. (1,000 – 1,200) x 1.05 – 400 x $\sqrt{1.05}$ – 110 – (−849 – 0) = 119.

The analysis of profit can be presented as in Table 12.17.

Table 12.17: Analysis of profit results

Item	Amount
Profit margins emerging (expected)	200
Claims experience profit	(51)
Lapse experience profit	(20)
Expense experience profit	(10)
Actual profit	119

In this example, the valuation assumptions were not revised. However, in practice, consideration will need to be given to whether claim, lapse or expense valuation assumptions were increased at the end of Year 1. This in itself could also be an item of surplus in Year 1.

12.4. Defined benefit funds

The method involved in an analysis of surplus for defined benefit (DB) funds is the same as that described in the step-through approach. However, there are differences in timing, ownership of data, and the drivers of experience when compared with life companies.

A full retirement liability valuation, including a reassessment of assumptions, is often conducted triennially. Part of the review involves projecting the financial position of the fund to the anticipated position in three years' time. Clearly, assumptions are required to complete the projection and these will be the fund actuary's best estimates of likely experience over the subsequent three years.

Successive fund reviews include an analysis of changes in actual surplus, against that expected. Actual surplus will differ to expected, as actual experience will differ from the assumptions used in the original projection. As with analysis of life insurance surplus or profits, the analysis involves the comparison of actual to expected experience (or expected to actual). The financial impact or contribution of each item of experience deviation is calculated.

The number of sources of surplus that are analysed will depend on the size and complexity of the fund and will be constrained by availability of suitable accounting and other information. Any surplus or deficit brought forward from the previous valuation will also form part of the analysis.

Exercise 12.3

Before you read the list below, think about what assumptions would be required to project cash flows in a DB fund.

Items that affect cash flows in a DB fund and, hence, may drive unexpected surplus arising, include experience relating to:

- investment return on last time's surplus;
- investment returns achieved on the assets;
- salary inflation;
- promotional salary scales;
- mortality pre-retirement;
- ill health retirements;
- withdrawal through resignation or dismissal;
- redundancies;
- retirement age;
- post-retirement mortality;
- new entrants;
- change in liability valuation basis;
- change in fund rules; and
- insurance premiums and rebates.

A discussion of the purposes of analysis of surplus was provided in Section 12.1, and this applies equally to DB funds. The analysis serves as a check on financial and actuarial results, provides the fund sponsor and trustees insight into emerging experience and helps guide the selection of valuation assumptions. The difference is that for a life company, the analysis is generally aimed at gaining an understanding of current and potential drivers of surplus and their implications for the management of the business. For a DB fund, the analysis is aimed more towards the assessment of experience factors affecting the pace of funding and their implications for future contribution rates.

The paper *An Introduction to Analysis of Surplus* by S. Ferris (1997)[2], presents a theoretical framework and a practical example of the application of an analysis of surplus for a DB fund. This paper provides an excellent introduction to students to the application of analysis of surplus to DB super funds. The approach is a step-through approach using formulae. We recommend that students read the paper and work through the numerical example.

12.5. Communicating outputs

The key messages coming out of the analysis of surplus must be communicated. An understanding of the drivers of surplus is essential if senior management are to make well-informed decisions regarding the future direction of the company or fund.

A great deal of detail and supporting analysis is generally available, and the selection and presentation of this to stakeholders is a key challenge. Communication of results should be structured to present important information succinctly, highlighting key issues. Similarly, care should be taken to avoid obscuring important information by presenting too many numbers or giving undue prominence to secondary details. Presentation of graphs, diagrams and tables can be valuable in communicating results that are complex or span multiple categories.

Communication of results should be presented according to their purpose and the intended audience. Communication of the processes undertaken should be succinct and accurate, addressing all material matters. On the other hand, reports to a broader audience should have clear messages, avoid unnecessary technical jargon and include sufficient explanation to avoid misunderstanding. Readers of reports will frequently need to deal with large amounts of information. Clear and concise messaging in reports will benefit both the reader and provider of information.

[2] Available from the Learning Management System

In presenting the results of an analysis of surplus, an actuary needs to be able to explain the underlying causes of each of the experience items. Investment experience can usually be explained by examining the performance of each of the main asset sectors that the life company or retirement fund invests in. Reports from investment managers can assist in this explanation. Changes to discount rates will reflect movements in risk-free interest rates. Claims experience for a life company could be attributable to random fluctuations, single events causing multiple claims, miss-estimation of the mean, adverse trends or changes in underwriting or claims management practices. If a life company has high retentions (i.e. low levels of reinsurance), claims experience can be quite volatile as it will be affected by the number of claims incurred for policies with high sums insured. The expense experience for a product will depend on the total expenses for the life company, how they are allocated to products, and how they are split between acquisition and maintenance categories. If the allocations change during the year, there can be significant expense experience surplus at product level.

The investigation into the causes of experience items could also expose operational issues such as:

- previously undiscovered errors in the company's administrative, accounting or investment systems;
- previously undiscovered errors in the methodology or systems used to calculate the values of in-force and new business;
- identification of areas where actual transactions differ from stated company or fund practice (possibilities include payment of policy owner benefits or refunding of policy premiums and commissions); and
- poor management of underwriting or claims.

A final point to note is that the techniques explained in this module may be applied to understanding changes in Module 14 (Capital) and Module 15 (Appraisal values).

12.6. Key learning points

- Due to the uncertainty involved in valuing future unknown cash flows, actual experience will never turn out to be exactly as expected. A key role of a life insurance or retirement actuary is to analyse and report on the actual experience which emerges over time.
- Surplus arising in a period can be calculated as $(A_1 - V_1) - (A_0 - V_0)$. It represents the difference between actual experience and valuation expectations.
- Surplus arising is usually a combination of planned surplus and unexpected surplus.
- An analysis of surplus is a process that aims to explain unexpected surplus by attributing it to various drivers. It provides a semi-independent check on the accuracy of the valuation and also helps guide the selection of valuation assumptions.
- For a DB fund, an analysis of surplus is used to guide the setting of future assumptions and determining contribution rates.
- For a life company, factors driving unexpected surplus typically include investment returns, mortality, morbidity, expenses, voluntary withdrawals and new business.
- An analysis of surplus can be conducted via a formula-based approach or a step-through approach. A step-through approach is more common these days.
- The drivers analysed and the order in which surplus is attributed to these drivers is a matter of choice. There is no single correct way or order for the analysis. The order in which items are analysed will affect the amount of surplus allocated to each component, but not the total amount of surplus arising.
- An important outcome of an analysis of surplus is its implications for the management of the business. For this reason, effective communication of the findings from an analysis of surplus is vital.

12.7. Appendix: reconciliation of surplus

The formula for mortality and miscellaneous surplus:

(A1) $$V_0(1+i) + (VPN - C - E^{\text{new}})\left(1+\frac{i}{2}\right) - V_{1,}$$

was split into three components: mortality, surrender and new business. This appendix reconciles the three components with Formula A1. The details are **not examinable,** but the analysis may provide the reader with an alternative understanding of the formula.

In A1, V_0 represents the opening reserve in respect of contracts that are still in force (IF) at the end of the year, contracts that exited through death (D), and those that exited through surrender (S). We can re-write the reserve as:

(A2) $$V_0 = V_0^{\text{IF}} + V_0^{\text{D}} + V_0^{\text{S}}.$$

The expression *VPN* represents the valuation reserve, net of expenses, that was actually received. This is because we have already analysed the renewal expenses and so we need the valuation premium net of actual renewal expenses. This distinction is important when we examine the mortality surplus and need to consider expected and actual valuation premiums received in respect of contracts that exit through death.

We can write:

(A3) $$VPN = VPN^{\text{IF}} + VPN^{\text{D}} + VPN^{\text{S}} + VPN^{\text{N}},$$

where VPN^{N} represents the new business valuation premiums, net of renewal expenses. Note that the expressions for death and surrender are the actual valuation premiums, not expected.

The claims can be split into:

(A4) $$C = C^{\text{D}} + C^{\text{S}}.$$

The closing reserve is in respect of surviving in-force business and new business:

(A5) $$V_1 = V_1^{\mathrm{IF}} + V_1^{\mathrm{N}}.$$

We have assumed that cash flows occur mid-year, which leads to the following relationships:

(A6) $$V_0^{\mathrm{IF}}(1+i) + VPN^{\mathrm{IF}}\left(1+\tfrac{1}{2}i\right) = EDS^{\mathrm{IF}} + V_1^{\mathrm{IF}}$$

(A7) $$V_0^{\mathrm{D}}(1+i) + E(VPN)^{\mathrm{D}}\left(1+\tfrac{1}{2}i\right) = EDS^{\mathrm{D}} + V_1^{\mathrm{D}}$$

The expression $E(VPN)^{\mathrm{D}}$ in A7 represents the expected valuation premium, net of renewal expenses.

We need to rewrite the mortality surplus, as the formula in 12.3 has netted-off an item. From first principles, the **mortality surplus** is:

Expected death strain less actual death strain plus actual valuation premiums, net of renewal expenses, received for contracts exiting through death less expected valuation premiums, net of renewal expenses, receivable for contracts exiting through death:

$$= EDS - ADS + VPN^{\mathrm{D}} - E(VPN)^{D} =$$

(A8) $$= EDS^{\mathrm{IF}} + EDS^{\mathrm{D}} + EDS^{\mathrm{S}} + EDS^{\mathrm{NB}} - C^{\mathrm{D}}\left(1+\tfrac{1}{2}i\right) + V_1^{\mathrm{D}} + (VPN^{\mathrm{D}} - E(VPN)^{\mathrm{D}})(1+\tfrac{1}{2}i),$$

where we have labelled the components of the EDS.

The **surrender** surplus is:

(A9) $$V_0^{\mathrm{S}}(1+\mathrm{i}) + (VPN^{\mathrm{S}} - C^{s})(1+\tfrac{i}{2}) - EDS^{\mathrm{S}}$$

The new business surplus is:

(A10) $$(VPN^{\mathrm{NB}} - E^{\mathrm{new}})\left(1+\tfrac{i}{2}\right) - V_1^{\mathrm{NB}} - EDS^{\mathrm{NB}}.$$

The sum of (A8), (A9) and (A10) is:

$$EDS^{\mathrm{IF}} + EDS^{\mathrm{D}} - C\left(1 + \tfrac{1}{2}i\right) + V_1^{\mathrm{D}} + (VPN^{\mathrm{D}} - E(VPN)^{\mathrm{D}})(1 + \tfrac{1}{2}i) \quad + V_0^{S}(1+i) +$$

$$VPN^{\mathrm{S}}\ (1 + \tfrac{i}{2}) + (VPN^{\mathrm{NB}} - E^{\mathrm{new}})\left(1 + \tfrac{i}{2}\right) - V_1^{\mathrm{NB}}.$$

Substitute in the values of EDS from (A6) and (A7), and collecting like terms, simplifies the equation to:

$$(V_0^{\mathrm{IF}} + V_0^{\mathrm{D}} + V_0^{\mathrm{S}})(1+i) + (VPN^{\mathrm{IF}} + VPN^{\mathrm{D}} + VPN^{\mathrm{S}} + VPN^{\mathrm{NB}} - C - E^{\mathrm{new}})\left(1 + \tfrac{1}{2}i\right) - V_1^{\mathrm{IF}} - V_1^{\mathrm{NB}}$$

$$= V_0\,(1+i) + (VPN - C - E^{\mathrm{new}})\left(1 + \tfrac{i}{2}\right) - V_{1,}$$

using the definitions in (A2) – (A5).

12.8. Answers to exercises

Exercise 12.1:

What two items have been ignored?

Answer:

- Expected interest on excess assets
- Change of basis

Exercise 12.2:

(i) What are the major sources of surplus for the following contracts: group income protection, variable annuity, and participating endowment insurance?

(ii) Explain why investment returns are not a key driver for term insurance.

Answer:

(i)

- Group Income Protection: Claims and lapses
- Variable annuity - depends on the type of VA. Possibly investment return if savings, longevity if guaranteed payout in drawdown stage. Lapses will also impact surplus.
- Par endowment - largely investment returns, contractual claims plus non-contractual claims (i.e. surrender), lapse

(ii) Relatively low reserves so investment returns have a relatively low effect.

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