Subject ST2

CMP Upgrade 2016/17

CMP Upgrade

This CMP Upgrade lists the changes to the Syllabus objectives, Core Reading and the ActEd material since last year that might realistically affect your chance of success in the exam. It is produced so that you can manually amend your 2016 CMP to make it suitable for study for the 2017 exams. It includes replacement pages and additional pages where appropriate. Alternatively, you can buy a full set of up-to-date Course Notes / CMP at a significantly reduced price if you have previously bought the full-price Course Notes / CMP in this subject. Please see our 2017 *Student Brochure* for more details.

This CMP Upgrade contains:

- all changes to the Syllabus objectives
- all significant changes to the Core Reading, ActEd Course Notes, Series X Assignments and Question and Answer Bank that will make them suitable for the 2017 exams.

1 Changes to the Syllabus objectives

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

Objective (c) has been shortened so that it now reads:

(c) Describe methods of distributing profits to with-profits policyholders.

The second bullet point under Objective (i) has been deleted so that it now reads:

(i) Describe the use of actuarial models, including stochastic models and Monte Carlo simulation, for decision making purposes in life insurance in terms of:
- the objectives and basic features of a life insurance model
- choosing between stochastic and deterministic approaches
- the use of sensitivity analysis or the assessment of variances
- the uses of models

An additional bullet point has been added at the end of Objective (o) so that it now reads:

(o) Describe how supervisory reserves and solvency capital requirements may be determined for a life insurance company, including:
- the reasons why the assumptions used may be different from those used in pricing
- market-consistent valuation
- the calculation of non-unit reserves
- the interplay between the strength of the supervisory reserves and the level of solvency capital required
- Value-at-Risk (VaR) capital assessment.
- comparison of passive and active valuation approaches.

The third bullet point under Objective (q) has been updated so that it now reads:

(q) Describe how the actual experience of a life insurance company should be monitored and assessed in terms of:

- the reasons for monitoring experience
- the data required
- the analysis of mortality, persistency, expense and investment experience
- the reasons for analysis of surplus and
- the reasons for analysis of embedded value profit
- the use of the results to revise the models used and assumptions.

2 Changes to the Core Reading and ActEd Course Notes

This section contains the most ***significant*** changes to the Core Reading and ActEd text. However, if you wish to have all the changes to the ActEd Course Notes you will need to buy a full replacement set of the up-to-date version (which you can do at a significantly reduced price if you have previously bought the full price Course Notes / CMP in this subject).

Chapter 3

Page 3

The following two paragraphs have been added at the bottom of the page:

However it is possible in some jurisdictions to "sell" an annuity in payment within a secondary market and thus convert the outstanding regular benefit payments into a cash lump sum.

You may have heard that the UK government intends to allow policyholders to sell their pension annuities in this way. The purchaser will need to assess the health of the policyholder and will pay substantially less to those in ill-health.

Chapter 8

Page 4

The third paragraph of Core Reading and the following paragraph of ActEd text have been updated as follows:

> **In a life insurance company, "persistency" is used to refer to the rate of retention of policies that is experienced by the company. If a company has "poor persistency", this indicates a high level of lapses, surrenders, partial withdrawals and/or conversions to paid-up status.**
>
> So an example of the *persistency risk* mentioned in the Core Reading above is the risk that the policyholder lapses or surrenders early. Persistency risk is also referred to as withdrawal risk.

Chapter 10

Page 12

Additional text has been added at the end of Section 4. Replacement page 12a is attached and includes all the new text.

Chapter 14

Page 7

A number of changes have been made. Replacement pages are attached.

Pages 9 and 10

Section 2 has been deleted.

Page 12

The fourth bullet point has been deleted.

The section headed "Cashflow versus formula" has been deleted.

Page 15

Solution 14.3 has been deleted.

Chapter 15

Page 15

The last paragraph of ActEd text has been replaced by the following two paragraphs:

A stochastic solvency projection can involve many thousands of simulations to project the assets and liabilities into the future. However, to calculate the liabilities at a given point in time in a particular simulation may require many thousands of further simulations (*eg* stochastic modelling may be required to place a value on any guarantees or options at each valuation date). This leads to the problem of simulations within simulations that we mentioned in Chapter 14. The simulations to calculate the value of the options and guarantees at time t are "nested" within the simulations that project forward the liabilities for every year.

The computing power available may not be able to cope with the necessary thousands of simulations each involving thousands of simulations (particularly given the time constraints for producing the results). So approximations, such as the Black-Scholes formula to calculate the value of any guarantees within the liabilities, may be required to speed things up.

Chapter 17

Pages 18 and 19

A number of changes have been made so that Section 1.6 is now expressed in terms of persistency rather than withdrawals. Replacement pages are attached.

Similar changes are made throughout the chapter so that references to withdrawals have mostly been replaced by references to persistency. Note that "increased withdrawals" is consistent with "reduced persistency".

Chapter 19

Changes have been made throughout this chapter. Replacement pages are attached.

Chapter 20

Page 3

The last paragraph of Core Reading has been updated as follows:

However, some regimes (including in the European Union) have adopted the use of best estimate or market-consistent assumptions in base reserves. In that case, the underlying basis could be the same for both pricing and reserving, but additional allowances for risk would be needed for each.

Page 9

The paragraph of ActEd text in the middle of the page has been updated as follows:

So we calculate the amount of capital we are required to hold in excess of our market-consistent estimate of the liabilities.

Section 4

A new section has been added on active and passive valuation approaches. The summary and solutions have been updated to include this new material. Replacement pages are attached.

Chapter 28

Page 15

The following point has been added to the list of bullet points:

- The risk appetite of the company.

Chapter 30

Pages 9 to 14

A number of changes have been made to Sections 3.3 and 3.4. In particular, references to withdrawals have mostly been replaced by references to persistency in Section 3.3. Also, the definitions of direct and overhead expenses have been updated and additional explanatory text has been added. Replacement pages are attached.

Page 16

The first paragraph of Core Reading has been updated as follows:

It is found in practice that most of these expenses are proportional to the number of contracts written or in-force. Exceptions can include:

- **marketing expenses – may be related to the amount of initial commission paid (if applicable);**
- **underwriting expenses – may be related to the size of benefit.**

Page 31

Section 5 has been extended. Replacement pages are attached.

Page 37

The first three points of Solution 30.6 have been updated as follows:

lowest persistency rates:	direct sales force
"medium" persistency rates:	direct marketing
highest persistency rates:	broker

Solution 30.6a

The solution to this new question is as follows:

The cumulative persistency rate is 50%, 40% and 36% for the first, second and third years respectively. So we see that the cumulative persistency rate falls with duration in force.

The persistency rate as measured over a year is the same for the first year, *ie* 50%. For subsequent years we must divide the number of surviving policies at the end of the year by the number in force at the start of that year. So the persistency rate for the second year is 40 / 50 = 80% and the persistency rate for the third year is 36 / 40 = 90%. So we see that in this case the persistency rate as measured over a year rises with duration in force.

The withdrawal rates are calculated as simply one less the persistency rate over the year. So the withdrawal rate is 50%, 20% and 10% for the first, second and third years respectively.

Glossary

The item for the **Contribution method** has been deleted.

The item for the **Negative non-unit reserve** has been updated to:

If projected non-unit income exceeds non-unit outgo on a unit-linked contract, it may be possible for a life insurance company to set up a negative non-unit reserve in respect of that contract. This may be subject to certain constraints, depending on the regulatory regime.

The following item has been added for the **Net premium valuation**:

This is a method for placing a value on a life insurance company's liabilities that involves calculating a present value of the contractual liabilities and deducting the value of future net premiums, allowing in each case only for mortality and interest.

The net premium is the premium, calculated on the basis of the valuation assumptions and payable under the same conditions as the office premium, that will provide the contractual benefits offered at the commencement of the policy.

The item for the **Non-unit reserve** has been updated to:

A company will have non-unit liabilities under its unitised contracts – for example the expenses of managing the business – for which it receives monetary payments in the form of the future charges it extracts. If it expects that the charges will not be sufficient to meet these liabilities at any point on a cashflow basis, it has to hold a non-unit reserve to provide for the deficiency.

Depending on the regulatory regime and any related constraints, it may be possible for a life insurance company to hold a negative non-unit reserve where it expects that future charges will be more than sufficient to meet the future non-unit liabilities.

The item for **Persistency** has been updated to:

In a life insurance company, "persistency" is used to refer to the rate of retention of policies that is experienced by the company. If a company has "poor persistency", this indicates a high level of lapses, surrenders, partial withdrawals and/or conversions to paid-up status. Persistency rates are typically measured over a defined period, such as a year, although may be expressed as a cumulative figure over the period since policy inception.

The item for **Terminal bonus** has been updated to:

A terminal bonus is a bonus that may be payable on maturity, death or surrender of a with-profits contract. It is typically a percentage, varying with duration in force and possibly with original policy term, of attaching regular reversionary bonuses and/or sum assured under a conventional with-profits contract, or of the accumulated benefit (allocated premiums – less any charges – **plus regular bonuses added to date) under an accumulating with-profits contract.**

The last paragraph in the item for **Unitised contracts** has been updated to:

Unitised contracts include unit-linked contracts and those accumulating with-profits contracts that are written on a unitised basis.

The item for **Unit reserve** has been updated to:

This is part of the reserve that a life insurance company needs to set up in respect of its unitised contracts. The unit reserve represents its liability in terms of the units held under the contracts.

3 Changes to the Q&A Bank

The most significant changes to the Q&A Bank questions and solutions are listed below. However, if you wish to see the fully amended versions, you will need to buy a new CMP (at a significantly reduced price), as indicated at the start of this upgrade.

Q&A Bank Part 2

Part (ii) of Question 2.4 has been changed to:

(ii) Explain the difference between management expenses and overhead expenses, and give one example of each. [3]

The first point in part (ii) of Solution 2.4 has been replaced by:

Management expenses consist of expenses that are incurred as a direct consequence of the existence of a policy. They occur when policies are written (new business), maintained (in-force business) or terminate (*eg* death, surrender, maturity). [1]

Q&A Bank Part 4

Part (ii) of Question 4.4 has been changed to:

(ii) Give a formula that could be used to derive the paid-up value by equating the realistic prospective value of the annual premium policy with a realistic prospective value of the paid-up policy, defining any terms used. [3]

[Total 6]

Solution 4.4 for part (ii) has now been updated to:

At the date of conversion to paid up, the following equation can be used:

$$SA \times A_{x+t:\overline{n-t}|} + R\ \ddot{a}^{(12)}_{x+t:\overline{n-t}|} - P\ \ddot{a}_{x+t:\overline{n-t}|} = PUSA \times A_{x+t:\overline{n-t}|} + R'\ \ddot{a}^{(12)}_{x+t:\overline{n-t}|}$$

[2]

where:

P	=	annual premium (before conversion)
SA	=	sum assured (before conversion)
$PUSA$	=	paid up sum assured
R	=	level of monthly renewal expense before conversion
R'	=	level of monthly renewal expense after conversion
t	=	duration
n	=	original policy term. [1]

The renewal expenses might be marginally lower for the paid-up policy as no premiums need to be collected.

[Total 3]

Question 4.5 has been deleted.

In Solution 4.9 part (ii), the fifth point on page 10 has been replaced by the following three points:

As the annuities are reasonably long-term predictable liabilities (assuming that the portfolio is large enough to remove random fluctuations)… [½]

…then (depending on the purpose of the valuation and any regulations) it may be appropriate to take credit for the illiquidity premium and thereby discount liabilities at a higher yield than the risk-free rate described above. [½]

However in reality, the liability cashflows are not certain amounts, but are instead subject to uncertainty. [½]

Also in Solution 4.9 part (ii), the following point has been added after the ninth point on page 10:

Alternatively, an overall reserving margin in respect of these risks could be determined using the "cost of capital" approach. [½]

In Solution 4.11 part (ii), the following has been added immediately after the heading "Non-unit reserve":

Prudential valuation

Under a regulatory regime which requires mathematical reserves to be prudent (rather than best estimate), the non-unit reserve is typically defined as the amount required to ensure that the company is able to pay claims and meet its continuing expenses without recourse to further finance. [1]

Also in Solution 4.11 part (ii), the following has been added to the end of the solution:

Best estimate valuation

Under a regulatory regime which requires mathematical reserves to be best estimate, the calculation of non-unit reserves would value all future non-unit cashflows, *ie* it would not disregard cashflows occurring after the last projection period in which there is a net outflow, and there would be no other restrictions. [1]

Under a best estimate (or market-consistent) valuation, it would generally be the case that negative non-unit reserves can be held. [½]

New Questions 4.17, 4.18 and 4.19 have been added. Replacement pages are attached.

Q&A Bank Part 5

A new Question 5.18 has been added. Replacement pages are attached.

Q&A Bank Part 6

Questions 6.3 and 6.12 have been deleted.

A new Question 6.18 has been added. Replacement pages are attached.

In Solution 6.9, the fifth and sixth points on page 14 have been updated to:

This will give the basic loadings, which may need to be adjusted for prudence (depending on the valuation regulations). [½]

They also should consider how expenses will inflate in the future, on a prudent basis if necessary. [½]

In Solution 6.15, the second point in part (i) has been replaced by the following two points:

Projections may be done on a policy by policy basis using the actual in-force policy data. [½]

Or model points could be used. These must reflect, by type and volume, the actual distribution of the in-force policies of the company. [1]

Also in Solution 6.15 part (i), a new point has been added between first and second points on page 24:

As a full projection of future solvency might require nested stochastic calculations, the company may adopt a simplified approach, eg a closed form solution or proxy model. [½]

In Solution 6.15 part (ii), the heading of "Withdrawal rates" has been changed to "Persistency" and the following new point has been added:

The analysis would consider full withdrawal, and if appropriate also partial (or income) withdrawal and conversion to paid up. [½]

4 Changes to the X assignments

As with the Q&A Bank, we have updated questions and solutions for the changes in the Core Reading and ActEd text.

We only accept the current version of assignments for marking, ie those published for the sessions leading to the 2017 exams. If you wish to submit your script for marking but have only an old version, then you can order the current assignments free of charge if you have purchased the same assignments in the same subject the previous year (ie sessions leading to the 2016 exams), and have purchased marking for the 2017 session.

The most *significant* changes to the assignment questions or solutions are listed below:

X1.4

In the solution, the heading "Withdrawal", and the first point beneath it, have been updated as follows:

Withdrawal (persistency) [½]

The company has largely protected itself against persistency risk by giving only the lower of premium paid and indexed value, which will mean that on withdrawal the asset share will usually exceed the surrender value, often by a considerable margin. [½]

X1.7

In the solution to part (i)(c), the eighth point has been updated as follows:

Charges may be deducted from the benefit fund. These could be any of the charges described for unit-linked, and essentially operate in an identical way except for the way in which the accumulating fund benefit is calculated. [½]

In the solution to part (ii), the last point has been updated as follows:

There may be tax advantages to such an arrangement, *eg* by reducing the liability to inheritance tax. [½]

X2.2

In the solution to part (ii), the first point has been updated as follows:

A significant risk is low persistency rates, which generally leads to losses or to a reduction in profitability. [½]

X2.7

The following section has been added to the solution:

Investment risk

The sum at risk is the death benefit less the value of the unit fund. [½]

So the insurer is exposed to investment risk whenever the sum at risk is positive. [½]

Many unit-linked contracts include a mortality charge that is related to the sum at risk, so that the charge would be higher whenever unit values fell. However, for this contract the mortality charge is taken as a percentage of the premium, so the insurer is exposed to investment risk in relation to the death benefit (at least until the next charging rate review date).

X3.3

Part (i) of this question has been replaced by a new question. Please refer to the 2017 materials for the new question and solution.

X3.4

In "Step 2" of the solution, the third bullet point has been updated as follows:

- demographic factors (mortality, persistency rates)

X3.6

In the solution to part (i)(b), the first and fifth points have been updated as follows:

There is a risk that the option to increase the benefit is used more often than expected. This is a risk because the value of the 10% increase in sum insured is greater than the value of the 10% increase in premiums (*ie* the unit fund might not be large enough to support the higher mortality charges required to meet the higher benefits). [1]

After ten years, the company may have difficulty in increasing charging rates as policyholders may surrender their contracts in response. [½]

X3.7

Part (ii) of the question has been updated as follows:

(ii) Suggest four modifications to this product's design that would improve its marketability, and comment briefly on how these modifications would affect the modelling performed in part (i). [4]

X4.2

The solution has been substantially rewritten. Please refer to the 2017 materials for the new solution.

X4.5

The question has been updated as follows:

The supervisory authority of the country where your life insurance company operates has decided to strengthen the supervisory solvency regulations. It has just issued the following statement:

"In order to ensure that life insurance companies are capable of meeting their future financial commitments as they fall due, and having regard to the uncertainties prevalent in the economy, in the life insurance marketplace and in the field of human health, as from 31 December 2016 all life insurance companies will be required to reduce the valuation rate of interest specified in legislation from its current level of 6.5% to a new level of 4.5%. In addition, companies must hold solvency capital to cover the following stresses:

(a) per-policy administration expenses increase over the next year by 25%

(b) the mortality of life assurance policyholders immediately worsens by 5%, while that of annuitants improves by 1% *pa* more than previously assumed."

Discuss what effect the changes might be expected to have on the solvency requirements and financial management of life insurance companies. [15]

X4.5

The solution has been updated in line with the changes to the question, *eg* in many places references to "reserves" have been changed to "solvency requirements". Please refer to the 2017 materials for the new solution.

X4.6

In the solution to part (iii), the heading "Withdrawals" has been changed to "Persistency". The first, third and fifth points have been updated as follows:

This would be difficult to estimate since the company has only three years' data. [½]

Note that the company has no experience of persistency rates at policy durations of greater than three years. [½]

Care will be needed in using any information because persistency rates vary considerably over time and for different target markets and sales channels. [½]

X4.9

This question has been replaced by a new question. Please refer to the 2017 materials for the new question and solution.

X5.1

The following points have been added to part (i) of the solution:

We have assumed that everyone will exercise the guaranteed annuity option if it is in the money (as this is the most prudent assumption to make). [½]

Similarly, we have also assumed that there are no surrenders (or transfers to other pension providers). [½]

Credit should also be given for other assumptions regarding option take-up rates and surrender as long as they are reasonably prudent.

X5.1

The following point has been added after the second point in part (iii) of the solution:

Although some policyholders might still prefer to take the cash now (if allowed by regulation) even if the annuity guarantee was more valuable. [½]

The last point in part (iii) of the solution has been updated as follows:

In addition, we would use a lower, less prudent, percentile to value the guarantee, *eg* 90% rather than the 97.5% used in reserving. [1]

X5.4

The following point has been added in relation to using risk premium as a form of financial reinsurance:

However, this form of financial reinsurance may not be effective under accounting or supervisory regimes where a realistic liability has to be held in respect of the increased risk premiums. [½]

X6.3

The question has been updated as follows:

A life insurance company is reviewing its premium rates for term assurance. Discuss how it could determine an appropriate persistency assumption to use in the profit test.

[12]

X6.3

The solution has been substantially rewritten. Please refer to the 2017 materials for the new solution.

X6.6

The first paragraph of this question has been updated as follows:

You are the actuary responsible for experience investigations in a large life insurance company. The Managing Director of the company has noticed that the company's persistency rates appear higher than those shown in the analysis of industry persistency produced by ALAC, the Association of Life Assurance Companies. However, your last report on persistency rates showed that, for your major product classes, persistency rates seem lower than those of your main competitors. The Managing Director, not trusting your results, has suggested that it would be more prudent if the company were to use the ALAC rates for future pricing, reserving and embedded value work.

X6.6

A number of changes have been made to the solution, primarily to refer to persistency rather than withdrawals. Please refer to the 2017 materials for the new solution.

5 Other tuition services

In addition to this CMP Upgrade you might find the following services helpful.

5.1 Study material

We offer the following study material in Subject ST2:

- Mock Exam A
- Additional Mock Pack
- ASET (ActEd Solutions with Exam Technique) and Mini-ASET
- MyTest
- Sound Revision
- Revision Notes
- Flashcards
- Online Classroom.

For further details on ActEd's study materials, please refer to the 2017 *Student Brochure*, which is available from the ActEd website at **www.ActEd.co.uk**.

5.2 Tutorials

We offer the following tutorials in Subject ST2:

- a set of Regular Tutorials (lasting three full days)
- a Block Tutorial (lasting three full days)
- a Revision Day (lasting one full day).

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

5.3 Marking

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

For further details on ActEd's marking services, please refer to the 2017 *Student Brochure*, which is available from the ActEd website at **www.ActEd.co.uk**.

6 Feedback on the study material

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

If you have any comments on this course please send them by email to **ST2@bpp.com** or by fax to **01235 550085**.

So we can see that expense risk can arise in many different ways and this can affect the way that the risk is classified. There is no single unique way to classify risk, but a common approach is described below.

The risk that actual expenses are higher than expected or allowed for, including (but not restricted to) due to the effects of inflation, is classified as expense risk.

The risk that the charges received are lower than expected or allowed for is more typically classified as other types of risk, depending on the underlying driver of the shortfall. For example, it may be

- **investment performance risk (*eg* if the charges are fund-based and the shortfall is due to low fund values as a result of poor investment returns)**
- **persistency risk (*eg* if charges required to recoup initial expenses are not received due to high withdrawal rates)**
- **new business mix or volume risk (*eg* to the extent that charges are linked to average size or volume of new business and this is lower than expected).**

New business mix and volume are considered further in the following chapter.

This second point can therefore lead to spurious accuracy: the great complexity of the model may give the appearance of highly precise answers, but if we have little confidence in the parameter values then we can have little confidence in the answers being correct. It's the old saying: rubbish in equals rubbish out!

The circumstances in which a deterministic approach may be appropriate include:

- **The actuary is satisfied that similar results could be obtained as if a full stochastic projection was used, *eg* the possible outcomes form a symmetric distribution and information is only required on the expectation, or if a specific scenario is being tested within a simple cashflow model.**

- **A quick, independent test is required to see that the results of a stochastic projection are reasonable.**

A single deterministic result – using average assumptions – together with a series of further deterministic calculations on amended assumptions, may in simple cases be used to provide upper and lower bounds on the corresponding stochastic result.

This is essentially the process of sensitivity testing, which we describe more fully at the end of Chapter 15 (and where we also revisit the circumstances under which deterministic or stochastic approaches would tend to be used).

Question 14.2

State with reasons whether you would use a deterministic or a stochastic model for the following purposes:

(a) Assessing the estimated loss to your portfolio of term assurance policies if there was an influenza epidemic as serious as that in 1918.

(b) Estimating the expected value and variance of term assurance claims next year.

(c) Estimating the cost of adding a minimum maturity value to a unit-linked product.

(d) Estimating the probability of insolvency due to an unforeseen AIDS epidemic.

(e) Calculating the bonus earning capacity of a particular block of with-profits policies.

(f) Estimating the free assets required to support the cost of smoothing with-profits bonus distributions in future years.

A deterministic or closed-form approximation approach may be needed within a stochastic projection to avoid having a "nested" stochastic model (*ie* one which requires stochastic projections within each stochastic simulation). We will meet this idea again when we consider dynamic solvency testing in Chapter 15.

For example, we have seen above that it may be preferable to calculate the value of liabilities which include options and guarantees using a stochastic model. However, if we then want to project the liabilities in many stochastic simulations we will end up with simulations nested within simulations. To avoid this complexity we may prefer to value the liabilities using a simpler approach, *eg* the Black-Scholes equation is a closed-form alternative to valuing options using simulations.

Calibration of stochastic models

For a stochastic model in which the economic assumptions vary, there are different approaches to the setting ("calibration") of these parameters. The most common are as follows:

- **Risk neutral (also known as "market-consistent") calibration – which in many countries is typically used for valuation purposes, particularly where there are options and guarantees. The focus of these calibrations is to replicate the market prices of actual financial instruments as closely as possible, using an adjusted (risk neutral) probability measure.**

  The first step in a market-consistent calibration is to choose a number of financial instruments (usually derivatives) that you know the price for. A model is then built that can project the cashflows from these instruments in a range of scenarios. The parameters are then chosen in such a way that the average present value of the cashflows from the modelled simulations is sufficiently close to the known market price.

  The idea is that if the model can closely reproduce the observed prices of quoted assets, then the model should also provide market-consistent values for unquoted asset or liability cashflows.

- **Real world calibration – typically used for projecting into the future, for example for calculating the appropriate level of capital to hold to ensure solvency under extreme adverse future scenarios at a given confidence level. The focus of these calibrations is to use assumptions which reflect realistic "long-term" expectations and which consequently also reflect observable "real world" probabilities and outcomes.**

  With the real world calibration we determine the model parameters using our expectations of the future. These assumptions are then used to project the values of the assets and liabilities under each stochastic scenario.

To see the difference between the two calibrations, consider two investments: bonds with a market price of 100 and equities with a market price of 100.

If we used the risk neutral calibration, then the average present value of the cashflows from our model's simulations would be 100 for each investment, *ie* the model has replicated the observed market prices.

However, if instead we used the real world calibration, we would expect that on average the simulated cashflows from the equities would be higher than the bonds (as this is what usually happens in real life).

This page has been left blank so that you can keep the chapter summaries together for revision purposes.

These commission assumptions should take into account any intended extra payments made to salesmen, brokers *etc* on achievement of certain high production targets.

The treatment of expenses may be affected by the tax regime applicable; a life company taxed on "$I - E$" can allow for this tax in its expense assumption, by netting the expenses down appropriately, but this treatment must be consistent with that of its investment return (by assuming all of the investment return is also fully net of tax).

1.5 Inflation of expenses

An inflation assumption will be necessary to apply to loadings in respect of renewal administration and policy termination expenses. These will be affected primarily by earnings (rather than price) inflation, because the majority of an insurance company's costs are staff costs.

The following may be considered when setting the value of the inflation parameter:

- **current rates of inflation, both for prices and earnings**
- **expected future rates of inflation**
- **the differential between the return on government fixed-interest securities and on government index-linked securities, where such exist**
- **recent actual experience of the life insurance company or industry.**

The third approach is really just one way of arriving at the expected future inflation of the second point. Also it is only approximate – it will be out by the extent of any inflation risk premium implicit in the price of the government fixed-interest bonds.

The inflation assumption must be consistent with the future investment income assumption.

When pricing a contract, as we are here, we have to consider two distinct aspects of expense inflation:

- the inflation of expenses during the term of a future new policy, from the issue date to its termination date
- the inflation of all expenses between "now" (the date at which you are setting premium rates to be used in future) and the dates at which the future new policies are actually issued.

As an example of the second point, you might set your per-policy initial expense assumption at £250, but for a policy issued in one year's time it perhaps ought to be £260, for one issued in two years' time it should be £272, and so on.

So we need to make the *overall* future expense assumptions appropriate to the *future period over which we would expect the pricing basis to be used*. In the case above, for example, if we expected our basis to apply for the next four years, say, we might fix our initial expense assumption at £275, for all policies to be issued over the four-year period.

1.6 Persistency

If deriving premiums from a formula approach (as opposed to the profit testing emerging cashflow approach) it is unlikely that any allowance will be made for withdrawals. This is one of the weaknesses of the simple formula approach. However the resultant premium rates will need to be profit tested, and the basis for the profit testing will need to incorporate suitable persistency assumptions, *ie* the profit test will be performed assuming that some proportion of policyholders withdraw each year.

The persistency (full withdrawal, partial withdrawal and paid-up rates, where applicable) assumptions should reflect the expected future experience in respect of the contracts that will be taken out.

They will be based on an analysis of the company's recent experience. Ideally, this should relate to the contract being priced, but if no such experience exists or the available data are inadequate, then the experience under any similar contracts would be analysed.

If the company does not itself have adequate data, there may be industry wide experience that it could use.

The results of such analyses should be assessed to see if they have been affected by special factors such as an adverse economic situation in the country.

Example

An interesting example of such a special factor is that of mutual life companies demutualising. As soon as rumours of the imminent demutualisation start to appear, with the possibility of windfalls to policyholders, withdrawal rates decrease.

The company may then suffer a "backlog" of withdrawals immediately after distributing any such windfall!

Question 17.14

How would you expect a deterioration of the economic situation to affect discontinuance rates for the following contracts:

(i) regular premium term assurance

(ii) single premium whole life assurance

(iii) regular premium endowment assurance.

If the rates are to apply to a class of lives that is expected to have a different experience from that to which the analysed data relates, then adjustments may need to be made. This situation could arise due to a change in the benefits being offered or target market or distribution channel.

Question 17.15

What changes to benefits for a regular premium whole life contract might lead to reduced persistency?

Question 17.16

How might a change of distribution channel affect persistency rates?

Persistency rates are significantly influenced by economic and commercial factors, which are notoriously difficult to predict. Future persistency rates are therefore subject to considerable uncertainty and so it is essential to explore the sensitivity of the company's profits to variations in the future persistency experience.

1.7 Margins

The assumptions derived in previous sections are estimates of the expected values for the parameters.

Where a cashflow model is being used to price a life insurance contract, the risk to the company from adverse future experience may be allowed for, as described in Chapter 15:

- **through the risk element of the risk discount rate**
- **through using a stochastic approach**
- **through assessing what margins to apply to the expected values.**

If a formula model is being used for pricing, the first two approaches above are not available and the risk of adverse future experience would be allowed for by taking margins. However, such a model does not help the actuary to quantify what these margins might be and hence he or she must use judgement based on past experience.

The risk allowance is discussed further in the following section.

The important point from the above is that, by including a margin or margins somewhere in the basis, the risk from adverse future experience is reduced. The basis actually chosen for pricing, inclusive of margins, will fix the level of risk the company will be subject to once the product is issued at that price.

Let's consider each "method" of the Core Reading in reverse order.

Under the third approach, all margins could be incorporated in the assumptions for each individual parameter; and the risk discount rate would then (in theory) be the risk-free rate. Hence, for example, our assumption for the future investment return might be written as:

$$i' = i'' - m$$

where i'' is the best estimate of the future annual investment return, m is the margin and i' is the interest rate assumption in the pricing basis, inclusive of margin. Once the product is in issue, the company risks making less profit than it anticipated if i (the actual rate of return achieved) is lower than i'. So the larger the value of the margin m, the lower the probability that $i < i'$ and the lower the risk of making a particular loss.

Chapter 19

Supervisory reserves and capital requirements (1)

Syllabus objective

(o) Describe how supervisory reserves and solvency capital requirements may be determined for a life insurance company, including:

- *the reasons why the assumptions used may be different from those used in pricing*
- *market-consistent valuation*
- *the calculation of non-unit reserves*
- *the interplay between the strength of the supervisory reserves and the level of solvency capital required*
- *Value-at-Risk (VaR) capital assessment*
- *comparison of passive and active valuation approaches*.

(Covered in part in this chapter.)

0 Introduction

In this and the next chapter we deal with the determination of supervisory reserves and solvency capital for a life insurance company.

We will begin in this chapter with an overview of the main reserving methods. You should already be familiar with much of this material from Subject CT5, although there is some new material too (*eg* on the calculation of *negative* non-unit reserves). It is important that you are confident in using these reserving methods as you may be asked to use them in the exam, not only in reserving questions, but also when calculating surrender values (Chapter 21), determining alteration terms (Chapter 22) and valuing mortality options (Chapter 23).

In the next chapter, we will consider the assumptions to use when calculating these reserves, *eg* we will look at how we can make these reserves market consistent, and we will consider the need for additional solvency capital over and above these reserves.

1 Background

1.1 Purposes of reserves

There are two fundamentally different purposes for valuing the assets and liabilities of a life company:

- to demonstrate solvency to the supervisory authorities
- to investigate "the truth" realistically.

The demonstration of solvency to the regulators will involve a minimum valuation standard. The reason for having such a standard is to ensure that a life company is capable of meeting all of its guaranteed liabilities. Given that future experience is uncertain, the valuation standards may require that *prudent* assumptions are used in the valuation so as to make the chance of failing to meet liabilities acceptably small.

Note though that in some countries (including in the EU) there has been movement towards best estimate assumptions, with additional solvency capital held to make the chance of failing to meet liabilities acceptably small.

The important thing to note is that it is the *sum* of the reserves and solvency capital that matters and that in total they need to be prudent. The necessary prudence may be contained in the reserves and/or the solvency capital in accordance with the supervisory regulations of the country concerned.

A realistic valuation to quantify the "true" situation of the life company may be done for internal management purposes. Typical uses would be:

- to help to determine the long-term sustainability of profit distribution rates (such as bonuses) and hence to help determine current bonus declarations
- to help determine the realistic profitability of the company for the information of shareholders (*etc*) and management
- almost anything else to do with the life company's financial management.

1.2 Mechanics of reserve calculation

In this chapter we will focus on the gross premium approach to valuation. A gross premium valuation can be performed using either a formula approach or a cashflow approach. However, other methods are used in various parts of the world, *eg* you will have seen the net premium valuation method in Subject CT5.

2 Gross premium valuation method

The Core Reading glossary definition is:

… a method for placing a value on a life insurance company's liabilities that explicitly values the future office premiums payable, expenses and claims, with the latter possibly including future discretionary benefits.

So the reserves for any policy are:

$$\begin{aligned} & \{\text{Present value of expected future claims}\} \\ + \quad & \{\text{Present value of expected future expenses}\} \\ - \quad & \{\text{Present value of expected future premiums}\} \end{aligned}$$

2.1 Gross premium formula method

The gross premium valuation method can often be expressed as a formula. For instance, for a regular premium without-profits endowment assurance, the formula would be

$$SA.A_{x+t:\overline{n-t}|} + RE.\ddot{a}_{x+t:\overline{n-t}|} - P'.\ddot{a}_{x+t:\overline{n-t}|}$$

where: SA = sum assured

RE = renewal expenses

P' = office premium.

Usually contracts are priced so that the present value of the premiums exceeds that of the claims and expenses (*eg* in order to make a profit). So the reserves should theoretically be negative just before the payment of the first premium.

Once the contract has begun, we no longer need to reserve for initial expenses or the first premium. The initial expenses are often much higher than the first premium paid on a regular premium policy, and this leads to reserves becoming even more negative.

However, any prudence in the reserves (relative to the pricing assumptions) may lead to reserves being positive even at policy commencement.

For a simple regular premium non-linked without-profits policy, the cost of the benefit payments will generally increase during the policy term, but the premiums received are level. Renewal expenses may be assumed to be level but, more realistically, to increase with inflation each year (for example, by calculating the expense annuity value at rate of interest $(i-f)/(1+f)$, where i is the valuation rate of interest and f the annual rate of inflation). Therefore, the value of future benefits plus expenses will almost always exceed premiums (except very early on in the contract), giving a smooth progression of reserves, which start negative and finish with a value equal to the final benefit payment.

2.2 Gross premium cashflow method

Alternatively, a gross premium valuation can be calculated using a cashflow approach, *ie* where the net cashflows are calculated for each future point in time.

Question 19.1

In what circumstances might it be better to calculate reserves using a cashflow approach rather than a formula?

A cashflow approach can be used for any type of contract, but is particularly useful for valuing unit-linked contracts. In this case we refer to the gross premium cashflow reserve as a non-unit reserve as described in the next section.

2.3 Non-unit reserves

Background

In the case of unit-linked business the cashflow to the company is the income from charges less the outgo in terms of expenses and claims in excess of the unit reserve. The complexity of these contracts – in particular the greater variety of patterns of cashflow that they produce – make a cashflow approach essential. The pattern of income and outgo will not necessarily be "smooth" as was the case for the endowment in Section 2.1.

The structure of a unit-linked contract is such that the company's liability is denominated partly in terms of units and partly in monetary (*ie* non-unit) terms.

Question 19.2

One example of a non-unit liability is administration expenses. What other liabilities might be included here?

This leads to a requirement for both a unit and non-unit reserve. The non-unit reserve is also often referred to (in the UK) as the sterling reserve.

The Core Reading definition of a unit reserve in the Glossary is:

… part of the reserve that a life insurance company needs to set up in respect of its unitised contracts. The unit reserve represents its liability in terms of the units held under the contracts.

Question 19.3

How would you calculate the unit reserve for a unit-linked policy?

The non-unit reserve is the present value of the excess of non-unit outgo (*eg* expenses, benefits in excess of the unit fund) over non-unit income (*eg* charges, unallocated premiums). A discounted cashflow method is used.

If the present value of the non-unit income exceeds that of the non-unit outgo, then the overall value would be negative. It may or may not be permitted for a negative non-unit reserve to be held, depending on the regulatory regime.

The precise details of the calculation will depend on the purpose of the valuation and any regulations that govern it. We will now cover in more detail the calculation of non-unit reserves for prudential valuations and best estimate valuations.

Prudential valuation

Under a regulatory regime which requires mathematical reserves to be prudent (rather than best estimate), the non-unit reserve is typically defined as the amount required to ensure that the company is able to pay claims and meet its continuing expenses without recourse to further finance.

In these circumstances, to calculate the non-unit reserve it is necessary to consider the year-by-year (and, at outset of the contract, possibly the month-by-month) incidence of the various components of the non-unit cashflows to determine if and when a non-unit reserve is required.

The company should project forwards its non-unit cashflows on the reserving basis. This may need to be performed on a policy-by-policy basis.

The non-unit reserve can then be calculated as follows:

- **The calculation process starts with the last projection period in which the net cashflow becomes negative.**
- **An amount is set up at the start of that period which is sufficient, allowing for earned investment return over the period, to "zeroise" the negative cashflow.**
- **This amount is then deducted from the net cashflow at the end of the previous time period.**
- **The process continues to work backwards towards the valuation date, with each negative being "zeroised" in this way.**
- **When the process has been completed, if the adjusted cashflow at the valuation date is negative then a non-unit reserve is set up equal to the absolute value of that negative amount.**

Example

A simple example of the above process is called for. Consider the following series of projected future cashflows (from the company's perspective), which are all expressed as amounts at the end of each year per policy in force at the start of the year:

Year	*1*	*2*	*3*	*4*	*5*
Cashflow	–3	10	2	–4	1

The last negative cashflow is the – 4 at time 4. So the reserve needed at that point (and for the whole of the preceding year, ignoring interest) is 4. One year earlier the reserve will be (4 – 2), *ie* 2. One year earlier than that the reserve needed is (2 – 10) *ie* – 8, but this is less than zero, so the reserve will be set to zero. One year before that the required reserve is (0 – (– 3)) *ie* 3, which is therefore the reserve required at the valuation date (*ie* at time 0).

In practice we would allow for interest and survivors. We would proceed as follows:

At the start of year 4, we need to hold the present value of the reserves that will be needed at time 4, for each policy in force at the start of the year. So the reserve required will be:

$$ {}_3V = 4v $$

Assuming interest at 4%, then ${}_3V = 3.85$.

So, looking forward again for a moment, this means that if the company holds reserves of 3.85 for each such policy in force at the start of year 4, then the company will have just enough money to meet the expected shortfall of 4 at the end of the year.

At the beginning of the previous year (year 3), we have to hold enough money to pay for the reserves required at the end of the year, for those who survive to the end of the year. But we are also going to receive a contribution of 2 towards meeting this cost, at the end of the year. If the age at the valuation date is x, and $(ap)_{x+t}$ is the probability of surviving between $x+t$ and $x+t+1$, then the reserve required will be:

$$ {}_2V = \left[3.85(ap)_{x+2} - 2\right]v $$

If we assume $(ap)_{x+2} = 0.99$, then ${}_2V = 1.74$.

The year before that, the reserve will be ${}_1V = \left[1.74(ap)_{x+1} - 10\right]v$ which is, of course, negative, as before, so would be set to zero. And so on.

Hence, while we often give examples ignoring interest and survival (because this makes it much easier to see what's going on), in real life you would certainly ***not*** *ignore these things! We have provided the above detail in this case to leave you in no doubt about what should be done. You should also recognise this from your earlier CT series courses.*

Best estimate valuation

Alternatively, non-unit reserves can be calculated for a best estimate valuation.

In such circumstances, the calculation would value *all* future non-unit cashflows, *ie* it would not disregard cashflows occurring after the last projection period in which there is a net outflow, and there would be no other restrictions.

Question 19.4

Consider the example above. Calculate the *best estimate* for the non-unit reserve required for each year, ignoring interest and survival.

In your solution to the question above, you should have calculated negative reserves for some of the years.

Under a best estimate (or market-consistent) valuation, it would generally be the case that negative non-unit reserves can be held.

The idea of a negative non-unit reserve might worry you. Firstly, why does it happen? Basically, a negative reserve will occur whenever the value of future positive cashflows outweighs the value of the negative cashflows. This can often occur for unit-linked contracts if future charges are expected to exceed future expenses and other costs.

So, what does this mean? If a contract has a negative reserve it means that we are treating the contract as an asset (*ie* more money is going to come in through future charges than go out through future costs). This sounds a reasonable approach for a best estimate valuation as the company realistically will make a gain from the contract.

In the following section we will look at negative non-unit reserves in more detail in the case of a prudential valuation.

2.4 Negative non-unit reserves

We will now look at negative non-unit reserves in the case of a prudential valuation.

Subject to certain conditions, it may be permissible to hold a negative non-unit reserve under a contract where future non-unit income is expected to be more than sufficient to meet future non-unit outgo.

The negative reserve represents a "loan" from other contracts which have positive non-unit reserves. The "loan" will be repaid by the emerging future profits from the policy for which the negative non-unit reserve is held.

When will negative non-unit reserves be held?

The primary constraint will be whether or not they are allowed by local regulation.

Regulations may specify that:

- **The sum of the unit and non-unit reserve for a policy should not be less than any guaranteed surrender value.**
- **The future profits arising on the policy with the negative non-unit reserve need to emerge in time to repay the "loan".**
- After taking account of the future non-unit reserves, there are no future negative cashflows for the policy, *ie* there should be no future valuation strain.
- **In aggregate, the sum of all non-unit reserves should not be negative.**

The positive reserves for the fourth bullet point could be from anywhere else in the company's business, not just from unit-linked policies. However, regulations might state that the negative reserves cannot be offset against the unit reserves.

In addition, does the company *want* to hold negative non-unit reserves? The answer may well be yes, because they will reduce the total reserve under a contract (*ie* the sum of unit and non-unit reserves), and hence improve the capital efficiency of the product.

When will a company be likely to use them? They can be used, in theory, whenever there are future positive cashflows that the company would like to take advance credit for.

With unit-linked designs, this is most likely to occur when, for example, a level allocation loading has been deducted from the regular premiums to recoup the heavy initial expenses. This will produce a large negative cashflow in the first policy year (because the company has just paid its initial expenses), followed by excess positive cashflows in future years.

Negative non-unit reserves can then be used to deduct, from the liabilities, the expected present value of these future positive cashflows. In other words, we are taking advance credit for the value of these future cashflows (*ie* the future contributions to the initial expenses that the company expects to receive) so that the new business strain is reduced.

Calculating negative non-unit reserves

A general algorithm for calculating non-unit reserves is as follows:

(1) Project the expected future non-unit cashflow from the policy, *ie* income from charges less outgo.

(2) Identify the last (most distant) cashflow (whether positive or negative).

(3) Set the reserve as an amount needed to meet that cashflow at that point in time (even if the cashflow is positive set the non-unit reserve as a negative amount).

(4) Check that the total reserve (*ie* unit plus non-unit) is greater than the surrender value (*ie* unit reserve less surrender penalty).

(5) Move back to the next previous cashflow, discount the reserve and then subtract from the reserve the new cashflow at the earlier time period. Repeat step (4).

(6) Carry on repeating the process working backwards over time to the valuation date.

(7) This will give the required non-unit reserve.

Example

Consider the same series of projected end-year future cashflows:

Year	*1*	*2*	*3*	*4*	*5*
Cashflow	–3	10	2	–4	1

Now you are told that there is a surrender penalty of 5 during the 1st year, 4 in the 2nd and so on, so the penalty is 1 in the 5th year.

The last cashflow is 1 at time 5. So the reserve needed just before that point (ignoring interest) is –1. Since there is a surrender penalty of 1, we can hold a non-unit reserve of –1 at the start of that year (*ie* at time 4).

One year earlier (at time 3) the reserve will be –1 – (–4), *ie* 3.

One year earlier (at time 2) the reserve will be 3 – 2, *ie* 1.

At time 1 the reserve will be (1 – 10), *ie* –9. However the surrender penalty is only 4 during that year, so the non-unit reserve will be set to –4.

At time 0 the reserve will be (–4 – (–3)) *ie* – 1 (which is OK since the surrender penalty is 5 during the first year).

Question 19.5

For practice, calculate the profit emerging at each of times 0, 1, … 5 in the above example, assuming we hold the non-unit reserves that we have just worked out. Ignore interest and survival.

Negative non-unit what?

Although the idea of a negative non-unit reserve may seem a little strange at first, it is really just a way of taking credit in advance for future positive cashflows that you expect on the contract.

However, for a prudential valuation we need to be careful not to take *too much credit* for future positive cashflows because, if future cashflows are smaller than we expected, then we could end up making a future loss. This means that our negative non-unit reserves should not be *too big* (in absolute value). So a prudent approach could be calculated by assuming that future positive cashflows are *lower* than best estimates, that the rate of interest used to discount them should be *higher* than best estimate, and that survival rates are lower than best estimates.

Note how this differs from the calculation of prudent *positive* non-unit reserves, for which a *lower* than best-estimate discount rate would be used.

Bear in mind that positive reserves are to meet future negative cashflows, so negative reserves are held against positive cashflows.

Also bear in mind that there should be adequate surrender penalties on the contract to ensure that, if the policyholder withdraws, the value of the future cashflows is not lost.

2.5 Features of the gross premium method

Looking now at the gross premium method at a generic level, whether we are using the simple formula approach or the more complex cashflow approach, it is possible to identify various salient features:

- an explicit allowance is made for expenses
- an explicit allowance can be made for bonuses
- the future premiums valued are the actual ("office") premiums expected
- any differences between the pricing and valuation bases will immediately be taken as profit or loss
- reserves may initially be negative for non-linked business, partly due to initial expenses and partly due to capitalising the expected future profit
- the reserves tend to be quite sensitive to changes in basis.

The fourth feature is a particularly important one: essentially the method will take credit for the present value of all the future profit that the company will make, if the future reality is as assumed in the reserving basis. Hence, if the valuation basis is more *lenient* than the premium basis (for example, if a realistic valuation was being carried out), then the company would "realise" all the future profits that it would expect to make on account of the future premium being larger than it needed to be according to this basis. On the other hand, were the reserving basis to be more prudent than the premium basis, then the company would be capitalising all the expected future *losses* that would arise if the reserving basis were to be borne out by reality.

We will return to the sixth feature at the end of the next chapter, where we will see that active valuation approaches can be sensitive to changes in market conditions.

Question 19.6

For an internal valuation of a life insurer's non-linked business, it has been suggested that a realistic gross premium valuation method is appropriate, because (realistically) we *do* wish to include the value of all the profits we expect to receive from the future gross premiums.

Comment on the validity of this suggestion.

Chapter 19 Summary

Liability valuation methods

Gross premium valuations can be carried out using a discounted cashflow approach or a formula approach.

Discounted cashflow method

- can be used for determining reserves for non-linked policies
- must be used for determining non-unit reserves for unit-linked policies
- positive non-unit reserves may be required to eliminate future negative cashflows in a prudential valuation
- negative non-unit reserves may be used to take advance credit for future excess positive cashflows, in order to reduce capital strain in a prudential valuation
- a best estimate valuation of the non-unit reserve would value *all* cashflows and there would generally be *no* restrictions on holding negative non-unit reserves.

Certain regulatory constraints may be imposed on the use of negative non-unit reserves in a prudential valuation, such as:

- The sum of the unit and non-unit reserve for a policy should not be less than any guaranteed surrender value.
- The future profits arising on the policy with the negative non-unit reserve need to emerge in time to repay the loan.
- After taking account of the future non-unit reserves, there are no future negative cashflows for the policy *ie* there should be no future valuation strain.
- In aggregate, the sum of all non-unit reserves should not be negative.

Gross premium (formula) method

- an explicit allowance is made for expenses
- an explicit allowance can be made for bonuses
- the future premiums valued are the actual ("office") premiums expected
- any differences between the pricing and valuation bases will immediately be taken as profit or loss
- reserves may initially be negative for non-linked business, partly due to initial expenses and partly due to capitalising the expected future profit
- the reserves tend to be quite sensitive to changes in basis.

Chapter 19 Solutions

Solution 19.1

A projected cashflow approach to calculating reserves has the following advantages:

- It can identify whether net cashflows in any particular period are positive or negative (which can be important as we will see in calculating non-unit reserves).
- The method can allow more easily for withdrawals.
- It can more easily cope with complex charging and benefit structures (*eg* unit-linked).
- It can more easily cope with charges and benefits which depend on future assumptions (*eg* bonus rates will change over time in response to investment returns, smoothing and PRE).
- It is easier to incorporate assumptions that vary over time, including stochastic assumptions.
- The risk discount rate can take account of the term structure of interest rates.
- It is easier to allow for the impact of reinsurance.
- Tax can be allowed for more appropriately.

Solution 19.2

Other aspects which might need to be considered here are:

- mortality costs if the death benefit is in excess of the unit reserve
- withdrawal costs if the guaranteed surrender value exceeds the unit reserve
- the future cost of other guarantees (*eg* minimum maturity benefits related to premiums paid)
- the future cost of policyholder options (*eg* option to convert the maturity payout to an annuity on guaranteed terms).

Solution 19.3

The unit reserve will simply be the number of units multiplied by their "bid" value (*ie* the price at which the life company is contractually obliged to buy the units off the policyholders).

Solution 19.4

The non-unit reserves can be calculated by starting with the last cashflow and working backwards as before. However, note that we must allow for all cashflows (both positive and negative).

The last cashflow is the 1 at time 5. So the reserve needed at that point (and for the whole of the preceding year, ignoring interest) is – 1.

One year earlier at time 4, the reserve will be (– 1– (– 4)), *ie* 3. Note that this is lower than the reserve of 4 than we obtained for the prudential valuation in the example.

At time 3, the reserve will be (3 – 2), *ie* 1.

At time 2, the reserve will be (1 – 10) *ie* – 9.

And for the first year the reserve will be (– 9 – (– 3)) *ie* – 6, which is therefore the reserve required at the valuation date (*ie* at time 0).

Note that there is no need to work backwards in this way for a best estimate calculation. The reserve can be calculated more quickly as $(-1) \times$ (the sum of all future cashflows). So the initial reserve is $(-1) \times (-3 + 10 + 2 - 4 + 1) = -6$ as before.

Solution 19.5

The reserves required are calculated in the example which precedes this question in the course.

The profit at each point is calculated as:

$$(\text{Reserve available}) + (\text{Cash flow}) - (\text{Reserve required})$$

and the reserve available at the beginning of the year is equal to the reserve required at the end of the previous year.

The calculations are summarised in the following table, and give the profit emerging at the end of each year.

Year	*0*	*1*	*2*	*3*	*4*	*5*
Reserve available	0	–1	–4	1	3	–1
Cashflow	0	–3	10	2	–4	1
Reserve required	–1	–4	1	3	–1	0
Profit	1	0	5	0	0	0

Solution 19.6

It is certainly appropriate to value the future gross premiums that we *expect* to receive, if we wish to assess the realistic value of the liabilities. (Consistent with this, we would include any calculated negative reserve values, rather than assume all such negative reserves were zero.)

However, we do not expect to receive all of the gross premiums – we should allow for those policies that terminate early due to death or withdrawal. While the gross premium formula method allows properly for mortality, it ignores future withdrawals. In this way, the gross premium formula method may not fully satisfy the requirements of an internal realistic valuation, but explicit allowance could be made by using the gross premium cashflow approach instead.

4 Active and passive valuation approaches

4.1 Passive valuation approach

A passive valuation approach is one which uses a valuation methodology which is relatively insensitive to changes in market conditions and a valuation basis which is updated relatively infrequently.

A change in market conditions can affect both the value of the assets and the value of the liabilities (*eg* if the valuation interest rate is derived from the yield available on assets). However, we will see below that under some valuation methods the value of the assets and / or the value of the liabilities change very little with market movements.

Under a passive valuation approach, the assumptions for mortality and expense inflation would rarely change.

An example would be the net premium valuation approach for liabilities (as described in Subject CT5), which is fairly insensitive to yield changes due to the net premium also being recalculated under the new assumptions.

Question 20.9

Describe how a net premium valuation would be calculated.

Question 20.10

Give a general formula for the net premium reserve for a regular premium without-profits endowment assurance. Define all the terms you use.

Question 20.11

Explain why the net premium valuation is relatively insensitive to changes in the valuation interest rate compared to a gross premium valuation.

Under passive approaches, assumptions may be "locked in". That is, they remain unchanged from those used when that policy was first written and the liability for it first determined. It may be a requirement, however, that non-economic assumptions are updated if experience worsens, in order to recognise the related loss and the need for higher reserves at that time.

So the same valuation interest rate may be used throughout the term of the policy (*ie* the interest rate is locked in). This might be considered acceptable because any increase (decrease) in interest rates would decrease (increase) both the value of the assets and the value of the liabilities. If assets are chosen that are well matched to the liabilities the true solvency of the company will be unaffected by market changes.

However, non-economic assumptions such as mortality may have to be varied over time because if experience deteriorates the cost of benefits will rise without any corresponding change in asset values.

For the valuation of assets, an example of a passive approach would be the use of historic cost or "book value", possibly with amortisation (or "write-down") over time.

By using a book value approach to valuing assets, we are ignoring the impact of changes in market prices. This might be suitable if the valuation of liabilities is also largely ignoring market conditions, *eg* if the valuation interest rate is locked in or if a net premium valuation is used.

Solvency capital requirements may be determined using a simplified approach such as holding a prescribed percentage of base liabilities.

So what are the advantages of using a passive valuation approach?

Passive valuation approaches:

- **tend to be more straightforward to implement**
- **involve less subjectivity**
- **(to the extent that they are used for accounting purposes) result in relatively stable profit emergence.**

Question 20.12

What do you think is the key disadvantage of a passive valuation approach?

4.2 Active valuation approach

In contrast, an active approach would be based more closely on market conditions, with the assumptions being updated on a frequent basis.

An example would be the use of market-consistent valuation approaches for both assets and liabilities, and a risk-based capital approach to solvency capital requirements.

The market-consistent valuation approach was described in Section 2 and a risk-based capital approach was described in Section 3.3.

What are the benefits of using an active approach?

Active valuation approaches are more informative in terms of understanding the impact of market conditions on the ability of the company to meet its obligations, particularly in relation to financial guarantees and options.

What are the disadvantages?

However, results are more volatile under such approaches and this has implications such as due to procyclicality. Under adverse equity market conditions (*eg* stock market crash), an active valuation approach using risk-based capital would indicate that higher capital requirements are needed. In order to reduce this requirement, companies would need to sell equities – which itself could exacerbate the market conditions. There is also systemic risk, as this would be the case for all life insurance companies at the same time. Therefore it may be the case that regulators include amendments to the valuation approaches under such conditions, to avoid this situation.

This is not just a theoretical risk. This is exactly what happened following the financial crisis of 2007/2008. As market prices fell (particularly for assets such as corporate bonds and equities) the solvency of banks and insurers also fell. To protect their solvency many of these financial institutions sold their risky assets and replaced them with safer assets such as government bonds. This meant that there was a huge supply of risky assets but very little demand, and so the market price slumped to a level far less than what many analysts would have regarded as the true value.

Question 20.13

What other disadvantages are there to an active valuation approach?

4.3 Combinations

The overall valuation approach may instead be somewhere between the two extremes, including elements of each.

This can result in a greater mismatch between assets and liabilities, and hence greater profits / losses or changes in free surplus when market conditions change. For example, an approach which uses a net premium valuation for liabilities and market value of assets could experience greater volatility of results than one which uses a market-consistent valuation for both.

Question 20.14

Explain the last sentence above.

Chapter 20 Summary

Reserving assumptions vs pricing assumptions

It is common in some countries to price prudently and then to define the reserving basis as the pricing basis.

This may be suitable for with-profits business as it can allow profit to emerge gradually and appropriately to the distribution method. It is less appropriate for without-profit business.

In other countries premiums may be calculated using broadly best estimate assumptions (and allowing for risk through a risk discount rate). In this case the pricing assumptions can not be used if the regulations require prudent reserving assumptions.

In other regimes there has been a move towards using best estimate or market-consistent assumptions in reserving. In this case the basis for pricing and reserving could be quite similar.

Market-consistent valuation

To determine a market-consistent value of liabilities, future unknown parameter values and cashflows are set so as to be consistent with market values, where a corresponding market exists. Market values are also used for assets, if market prices exist.

Future investment returns are based on a risk-free rate of return, irrespective of the type of asset actually held, and the discount rates are also based on risk-free rates.

Risk-free rates may be based on government bond yields or on swap rates. It may be appropriate to make a deduction to allow for credit risk.

Under certain conditions, it may be possible to take credit for the illiquidity premium available on corporate bonds and thereby discount liabilities at a higher yield than the risk-free rate.

It may be difficult to obtain a "market-consistent" assumption for some elements of the basis, such as mortality, persistency or expenses, for which there is not a sufficiently deep and liquid market in which to trade or hedge such risks.

It is then likely that a risk margin would be added to the best estimate of the liabilities. This risk margin would reflect the compensation required by the "market" in return for taking on those uncertain aspects of the liability cashflows.

This could be done by adding a margin to each such assumption or by using the "cost of capital" approach.

Solvency capital requirements

Insurance supervisory authorities normally require that life insurance companies establish a certain amount of solvency capital. This is to protect policyholders from a company reserving too little for their liabilities, and from the harmful effects of asset volatility. Supervisory reserving needs to be considered in conjunction with the solvency capital requirements, and *vice versa*.

The relationship between reserves and solvency capital requirements varies between different countries and regulatory jurisdictions. Normally it will be one of two cases:

- strong reserving, with a small solvency capital requirement
- weak reserving, with a large solvency capital requirement

where weak reserving means a basis close to best estimate.

The level of solvency capital required under regulation may be specified as a formula, or it may be based on a risk measure such as Value-at-Risk (VaR).

The VaR can be calculated by subjecting the supervisory balance sheet to stress tests on each of the identified risk factors, at the defined confidence level and over the defined period.

The aggregated capital requirement combines the separate stress tests to reflect any diversification benefits that exist between the various risks. This may be done through the use of correlation matrices or by copulas.

Passive and active valuation approaches

A passive valuation approach is relatively insensitive to changes in market conditions and has a valuation basis which is updated relatively infrequently.

An active approach is based more closely on market conditions, with the assumptions being updated on a frequent basis.

Passive approaches tend to be easier to implement, involve less subjectivity and result in relatively stable profit emergence. Active approaches are more informative in terms of understanding the impact of market conditions.

Chapter 20 Solutions

Solution 20.1

Without-profits business is likely to be priced using relatively small margins for competitive reasons. As a result, the pricing basis is unlikely to be sufficiently prudent to use for supervisory reserving. In contrast, with-profits business can be priced with large margins, as any future surpluses can be returned to policyholders through bonuses.

Solution 20.2

For a reserving basis, the discount rate *has to be* the investment return assumption, because a reserve is an assessment of the amount of assets needed to meet future liabilities, and as such is dependent on the return that those assets will earn in the future. The risk discount rate is a measure of the return that the shareholders require on their *capital*, it has nothing to do with the return that the company can earn on its assets, and hence is irrelevant to a calculation of the reserves.

Solution 20.3

The insurance company's solvency position would improve.

Under the old rules, the insurance company would have to discount its liabilities at the risk-free rate of 4%.

Under the new rules, the insurance company could add in the illiquidity premium so that it discounted its liabilities at 5%. The higher the discount rate, the lower the value of the liabilities, and hence the better the solvency position.

Solution 20.4

This is because the annuity cashflows are not of certain amounts, but are instead dependent upon how many (and precisely which) of the current annuitants survive to each future date. In other words, the cashflows are subject to uncertainty due to mortality.

Solution 20.5

Using best-estimate mortality assumptions would produce a value that was lower than the market-consistent value. This is because a purchaser of the liability would require additional compensation, for the possibility that the liability should turn out to be more expensive than expected.

Solution 20.6

We should assume lower mortality, as it is greater longevity that will increase the cost of these liabilities to our notional purchaser.

Solution 20.7

It will protect policyholders against:

- the reserves being underestimated (*ie* adverse future experience relative to the reserving basis assumptions), and
- a drop in asset values (including individual asset defaults).

Solution 20.8

$$\text{Aggregated capital requirement} = \sqrt{\begin{aligned}&100^2 + 10^2 + 20^2 \\ &+2 \times 0.5 \times 100 \times 20 \\ &+2 \times 0.5 \times 10 \times 20\end{aligned}}$$

$$= £112.69 \text{ million}$$

Note that as the risks are not 100% correlated with each other, the aggregated capital requirement is less than the sum of the capital requirements for each separate risk. This demonstrates the benefits of diversification amongst the risks.

Solution 20.9

The Glossary for Subject ST2 gives the following description of a net premium valuation:

This is a method for placing a value on a life insurance company's liabilities that involves calculating a present value of the contractual liabilities and deducting the value of future net premiums, allowing in each case only for mortality and interest.

The key point to note here is that the calculation ignores expenses. So a net premium valuation is the expected present value of the benefits less the net premiums.

The net premium is the premium, calculated on the basis of the valuation assumptions and payable under the same conditions as the office premium, that will provide the contractual benefits offered at the commencement of the policy.

The key point to note here is that the calculation makes no reference to the actual premium paid. Instead a net premium is calculated that ignores expenses and is calculated using the valuation assumptions (*ie* it does not use the pricing basis assumptions).

Solution 20.10

The net premium reserve at time t for a regular premium without-profits endowment assurance with constant premiums would be:

$$S.A_{x+t:\overline{n-t}|} - P.\ddot{a}_{x+t:\overline{n-t}|}$$

where: S = sum assured

P = net premium = $S.\dfrac{A_{x:\overline{n}|}}{\ddot{a}_{x:\overline{n}|}}$

x = age at outset

n = contract term

Solution 20.11

If the valuation interest rate decreased (say from 4% to 3%) then the value of the assurance factor $A_{x+t:\overline{n-t}|}$ and the annuity factor $\ddot{a}_{x+t:\overline{n-t}|}$ would both increase. However, the impact would be greatest for the assurance factor (as the benefits are paid later than the premiums and so are discounted for longer). So we would expect the reserve to increase for a gross premium valuation (assuming the reserve was positive).

However, for a net premium valuation we would also need to recalculate the net premium using the new valuation interest rate. A decrease in the interest rate would increase the net premium P. So the present value of the premiums would increase by more under a net premium valuation approach, and the increase in premiums would be closer to the increase in the benefits. So for a net premium valuation the impact of a change in the valuation interest rate is less than for a gross premium valuation.

Solution 20.12

A passive valuation is at risk, by its very definition, of becoming out of date. It is relatively insensitive to changes in market conditions and has a valuation basis which is updated relatively infrequently.

For example, if the stock market crashes then the book value of the assets will be overvalued relative to their value if sold in the market today. Similarly, the net premium valuation is relatively insensitive to changes in interest rates (as we described in the solution to Question 20.11).

If the valuation basis is changed infrequently then it may not have taken account of important trends, *eg* rising expense inflation or deteriorating claims experience.

So there is a danger that a passive valuation approach provides a false sense of security. Management may fail to take appropriate actions in response to emerging problems until too late, because the solvency position hasn't appeared to change.

Solution 20.13

An active valuation approach is likely to be more complex than a passive approach. So the calculations could take longer to perform and be more costly.

Solution 20.14

If the assets and liabilities are well matched, then the true impact of market movements on the company's solvency should also be quite small. Under an active valuation approach, any change in the value of the assets should be reflected in a corresponding change in the value of the liabilities (*eg* if interest rates fall then both valuations should rise), so the solvency position should be little changed. Under a passive valuation approach, the value of the assets and liabilities might be little changed by market conditions, so again the solvency position should be little changed.

However, if a combination of active and passive approaches is used then solvency might appear to change dramatically (when in reality it hasn't changed). A change in interest rates would change the market price of assets but would have little impact on the net premium valuation of liabilities.

Further classifications (*eg* by location, even down to postcode level) could be used if there is sufficient data.

Occupation (or at least broad occupational group) would also be a useful factor for a mortality investigation of temporary assurance contracts.

The process

The process for analysing experience has been examined in Subject CT4 and will not be re-examined here.

3.3 Persistency experience

Subdividing the data

The factors by which the data could be analysed, in rough order of importance, are:

- **type of contract – term assurances have different persistency rates from with-profits endowment assurances for example, as healthy policyholders may be more likely to lapse the former;**
- **duration in force – persistency rates (as measured over a specified period, *eg* month or year) are generally lower near the start of a contract;**

  For example, 95% of policies in force at the start of the fifth year may be in force at the end of the fifth year, but only 80% of policies in force at the start of the second year may be in force at the end of the second year.

- **sales method used and target market – the degree of care taken in ensuring that a suitable product is sold may depend on the sales method and target market. The more suitable the product the better will usually be the persistency experience;**
- **frequency and size of premium – with monthly premiums there are more opportunities to stop paying premiums than if premiums are annual; conversely, a larger annual premium may be considered less affordable than a smaller, regular payment. A high premium relative to income will be harder to afford than a smaller one, but it may not be considered worthwhile continuing to pay a small one;**
- **premium payment method – premiums paid in cash are more noticeable than premiums paid directly from a bank account and so lead to lower persistency rates;**
- **original term of contract;**
- **sex and age – *eg* experience tends to be worse for younger ages.**

Note that these are the factors by which persistency experience *could* be analysed. In practice, often only the first three factors will be considered, in order not to end up with a large number of almost empty cells.

The fourth and fifth points are not necessarily independent. For example, annual premiums are more often paid in cash than monthly premiums, which are often paid directly from a bank account. Hence annual premiums are usually more noticeable than monthly premiums for two reasons: being in cash and being large amounts. Persistency is likely to be lower for both reasons together.

Question 30.6

How would you expect persistency rates to compare for the following sales methods?

- broker
- direct sales force
- direct marketing telephone sales in response to newspaper advertising.

Persistency rates in the future are also affected by, amongst other things, the:

- **economic situation, and**
- **competitive situation of the product – *eg* the introduction of a more attractive product can have an adverse effect**
- **perceived value of the product to the customer.**

These would not usually be allowed for in an analysis of past experience but may be used to understand or explain patterns in this experience.

The process

For each homogeneous group to be analysed, full withdrawal rates can be determined as follows.

The number of contracts issued in the company's last financial year is divided into the corresponding number that survive in-force until the first policy anniversary to give a first year persistency rate. The first year withdrawal rate can be determined as one less the persistency rate.

Deaths and maturities should be excluded from the calculation (if material).

A similar procedure can be adopted to obtain the second year, third year, *etc* withdrawal rates, by looking at the number surviving from the number of contracts, in each group, that have their first, second, *etc* policy anniversary in the last financial year.

There are two possible approaches to calculating persistency rates in the second and subsequent years. Firstly, the persistency rate can be calculated over a defined period as the number surviving the year divided by the number in force at the *beginning of the year*. Secondly, the persistency rate can be calculated cumulatively as the number surviving the year divided by the number in force at the *outset of the contract*.

Question 30.6a

A company sells 100 insurance contracts. At the end of the first year only 50 contracts are still in force. At the end of the second year there are 40 contracts in force and at the end of the third year there are 36 contracts in force. Calculate the following:

- the cumulative persistency rate
- the persistency rate as measured over each year
- the withdrawal rate.

As the results are examined, it will be clear that for some groups there is little difference between withdrawal rates at different durations (for instance the difference in withdrawal rates for policies of duration twelve years compared with those of duration thirteen years), and intuitively a difference would not be expected. For some groups the differences emerging might seem to be statistical quirks stemming from small cell sizes (*eg* withdrawal rates for eighty-six year old policyholders). As a result of these considerations, the actuary would regroup the data and recalculate withdrawal rates for these broader groups.

After having finished the investigation itself to the greatest possible degree of *valid* accuracy (*ie* regrouping to avoid spuriously small groups), the presentation of results for management information purposes would probably require further consolidation depending on the level of management involved. For instance senior management would probably want results split by broad product class, not by every product.

In addition to analysing persistency into the groups described above (type of contract, duration *etc*) the analysis may be broken down to look at the different types of discontinuance as described below.

Analysis of policies that are made paid-up is normally done as a subsidiary part of the withdrawal analysis.

There may also be a related analysis of partial (or income) withdrawal rates, depending on product design.

3.4 Expense experience

Subdividing the data

One way to think of an expense analysis is to consider what are the desired end results of the process. The desired result will depend on the purpose of the investigation.

For some purposes it may be sufficient simply to know the expenses in total: for example a company can calculate its total profit over a year without performing a detailed expense analysis.

For other purposes this would be completely inadequate, however:

- if you use the contribution method then you will need to analyse expenses into policy groups so that the dividend can be properly calculated for each group
- when calculating asset shares – perhaps for determining terminal bonuses or terminal dividends, or when assessing appropriate surrender value scales – historical expenses have to be apportioned between different policy types
- for pricing and reserving it is essential that you establish a policy's fair share of the company's costs, so that the correct premiums or charges can be levied.

Ultimately, the expenses are a function of the work that the company does – *ie* administering a portfolio of life insurance policies. If you want to project the company's future expected expenses, then you will need to determine the relationship between the company's business – the policies it sells and maintains in force – and the expenses incurred in doing so.

In most of these cases, therefore, the main idea is that you want to be able to attribute the historical expenses to each policy that the company had on its books over the period during which the expenses were incurred. In other words what was policy X's fair share of the company's actual expenses over (say) calendar year Y?

But we need to be more sophisticated than this, in order to avoid significant model error at the modelling stage. For example, we need to identify a policy's share of the initial expenses separately from its renewal expenses. This is vital, for example, in order to estimate the likely capital strains of writing new business and therefore how much business you can afford to write.

Similar arguments lead to the conclusion that we need each policy's share of the expenses to be subdivided as follows:

- expenses relating to new business
- expenses relating to existing business
- expenses relating to terminations (*ie* deaths, maturities, surrenders, lapses – and possibly for each of these separately)
- expenses relating to investment management

And for each of the first three categories we need to identify whether the expenses are:

- proportionate to the premium payable under the policy
- proportionate to the benefit level (*eg* sum assured, annual amount of annuity) under the policy
- fixed amounts per policy.

Example

Suppose the historical expenses over one year for a particular annual premium assurance product line are as follows (arbitrary units):

	New business	Existing	Terminations
Per premium	500	1,000	0
Per sum assured	100	0	750
Per policy	200	5,000	250

Define:

$P(new)$ = total new annual premiums received during year

$P(exist)$ = total premiums received from existing policies during year

$S(new)$ = total sums assured under policies issued during year

$S(term)$ = total sums assured under policies terminating during year

$N(new)$ = total number of new policies issued during year

$N(exist)$ = average number of policies in force (excluding new business) during year

$N(term)$ = total number of policy terminations during year

Then we would calculate a policy's share as:

$$\text{Initial expenses} = \frac{500}{P(new)} \text{ per unit premium}$$

$$+ \frac{100}{S(new)} \text{ per unit sum assured}$$

$$+ \frac{200}{N(new)} \text{ per policy}$$

$$\text{Renewal expenses} = \frac{1,000}{P(exist)} \text{ per unit premium}$$

$$+ \frac{5,000}{N(exist)} \text{ per policy}$$

$$\text{and termination expenses} = \frac{750}{S(term)} \text{ per unit sum assured}$$

$$+ \frac{250}{N(term)} \text{ per policy}$$

After suitable adjustment for expected future changes to the experience, we could now use these results as assumptions in our projection models.

You will notice in the above example that we have described the amounts as all relating to a particular product line. Whether or not you subdivide your expense experience by product line, or by some other classification, depends on the nature of your business (and in particular, whether the expense contribution differs significantly between categories and whether the volume or quality of the data justify it).

An important consideration for an expense investigation is the time period involved.

Question 30.7

What time interval would you expect to use for an expense investigation?

The other important consideration in an expense analysis is the subdivision between direct and overhead expenses.

In theory, the expenses of a life insurance company can be divided into:

- ***direct expenses* – the expenses that can be attributed directly to a particular product or policy**

- ***overheads* – the balance of the expenses, *ie* those that relate to general management and service departments which are not directly involved in new business or policy maintenance activities.**

Direct expenses are typically variable (*ie* they depend on either the volume of new business or the level of in-force business), but may be fixed to some extent.

For example, the amount of underwriting performed will depend on the number of applications that need to be underwritten, *ie* it is a variable cost. However, we wouldn't expect to hire and fire underwriters on a daily basis depending on volumes, so underwriters' salaries are a fixed expense at least in the short term.

Overheads are more typically fixed costs (*ie* are insensitive both to the volume of new business and to the level of in-force business), but will be variable to some extent – often in step changes.

The cost of the head office building (rent, heating, lighting) is largely a fixed overhead. The head office will remain the same size regardless of how many policies sold in the month. However, large companies with lots of policies will have much larger head offices than small companies. As a company grows it may move to progressively larger premises, so this cost tends to vary in steps.

In practice, there is not a clear dividing line between these two categories, and some judgements will have to be made.

5 Using the results

We now consider how the results of all these investigations can be fed back into the Control Cycle.

The results of analysing the experience, the surplus arising and the change in the embedded value will be used by the actuary to reassess his or her view of the future with regard to the company. This may result in changes to the assumptions or models used for pricing or reserving, or changes to the ways in which the business and its risks are managed.

Thus, we go around the Control Cycle loop. This will be repeated continually.

For example:

(a) updating the pricing basis

For example, a deterioration in mortality experience generally could be mitigated by raising premium rates in the future (for new business only, unless premiums on existing policies are reviewable).

(b) revising product design

For example, an option might be removed if experience indicated that the option was rarely used or if the mortality of those taking up the option was very high.

(c) changing the product mix / launching new products

The company may decide to stop selling unprofitable lines of business and launch new products that have been successful for other companies.

(d) revising the underwriting processes

For example, the level of underwriting may need to increase if mortality rates are high for products with a significant death benefit.

(e) revising reinsurance arrangements

For example, volatile mortality experience could be smoothed using reinsurance.

(f) implementing or improving retention activity

This might improve persistency experience, but will incur costs.

(g) changing the marketing message, target market and/or distribution channel

For example, an analysis that shows poor new business volumes in one particular product may indicate that the advertising spend should be reviewed or that the product should be marketed in a different way.

(h) revising sales procedures in terms of training and selection of distributors, wording and format of sales literature and the mechanics of any commission payments and clawback

Monitoring cashflows may indicate, for example, that one particular broker has a poor administrative process resulting in lengthy delays in premium receipt. A tightening of the premium collection procedures might help in this case.

(i) improving the wording of policy contracts

For example, if the level of complaints is high.

(j) improving the adequacy of staffing resources (numbers and competence)

A rapid increase in new business will require an increase in the number of staff.

(k) improving systems and data recording processes

Improvements may be required to update the sophistication of the analysis, *eg* so that more rating factors can be analysed.

(l) improving actuarial models

For example, the rating factors used in a pricing model should reflect the factors that appear to be most significant in the analysis.

(m) changing the investment strategy

Volatile investment surplus may indicate that assets are poorly matched to liabilities.

(n) changing the with-profits surplus distribution approach

Changes in the surplus emerging may lead to changes in the split between reversionary and terminal bonus and the extent that the company wishes to smooth.

(o) updating the reserving basis

The reserving basis will normally be based loosely on past experience, subject to other constraints such as regulation.

(p) raising capital

If the surplus arising is negative, then capital may need to be raised.

(q) altering the capital allocation methodology

If experience has been poor for a particular line of business then more capital may need to be allocated to that line.

(r) improving risk management governance and controls.

The results of the various monitoring exercises will form the management information on which key decisions are made. The results may even change how these decisions are made, *eg* a risk management committee might meet more often if results become more volatile.

In essence, this is an iterative process. The actuary is trying to estimate how the company will progress in the future, based on what has happened in the past. Over time, the actuary should be able to collect more information and therefore improve the modelling of risks. However, historical data may become less relevant and there are likely to be unforeseen changes that mean that the process of experience monitoring is a continuous one.

Although assumptions should gradually home in on reality in the case of a static world, in the real world the ever changing nature of actual experience will prevent the actuary's assumptions from getting really close to reality. Thus our assumptions will normally need to contain margins.

Specimen Exam Question

A proprietary life insurance company that currently transacts a range of conventional business, is proposing to enter the unit-linked life insurance market.

Describe the procedures that should be established to monitor and control the unit-linked business. [10]

Question 4.17

A life insurance company sells term assurances with term of three years. Premiums are payable annually in advance. The sum assured of 50,000 is payable at the end of the year of death.

The pricing basis uses the following *best estimate* assumptions:

Mortality:		0.1% per annum
Interest:		3% per annum
Expenses:	initial:	70 incurred at outset
	renewal:	5 incurred when second and third premiums are received
	claim:	80 incurred when the death benefit is paid
Profit loading:		30

Note that the cost of capital associated with the solvency requirements has been ignored in the pricing calculation for simplicity.

(i) Show that the premium for this policy is 86.26. [3]

The regulator believes that the following assumptions would represent a *prudent* estimate of future experience:

Mortality:		0.13% per annum
Interest:		2% per annum
Expenses:	renewal:	6 incurred when second and third premiums are received
	claim:	90 incurred when the death benefit is paid

The regulator is prepared to allow companies to calculate reserves on a best estimate basis if they hold additional solvency capital calculated as 0.091% of the sum at risk.

(ii) The contract has just been sold, the premium has been paid and the initial expenses have been incurred. Calculate:

(a) the asset share

(b) the supervisory reserves calculated on the best estimate basis used in pricing (assuming there is no solvency capital requirement)

(c) the supervisory reserves calculated on the regulator's prudent basis (assuming there is no solvency capital requirement)

(d) the sum of the supervisory reserves calculated on the best estimate basis and the solvency capital requirement. [9]

(iii) Comment on the results of your calculations above. [3]

[Total 15]

Question 4.18

A life insurer sells term assurances.

Discuss the relative merits of using a passive valuation approach rather than an active approach. [6]

Question 4.19

A life insurer sells level immediate annuities.

It has the choice of the following assets to invest in:

- a large issue of low grade, long-term, fixed-interest corporate bonds, issued by a large domestic multinational company
- a small issue of high grade, long-term, fixed-interest corporate bonds, issued by a small, private local company
- long-term, fixed-interest government bonds.

The corporate bonds provide a similar expected yield, which is significantly higher than the government bond yield.

(i) Discuss which bonds would be most appropriate to back the annuity liabilities. [6]

(ii) Describe how the choice of bonds would affect the discount rate used to value the liabilities in a market-consistent valuation. [4]

[Total 10]

Solution 4.17

(i) ***Premium***

We calculate the premium P by equating the expected present value of the premiums with the expected present value of the claims, expenses and profit loading.

$$P\left(1+0.999v+0.999^2v^2\right)=50,080\times0.001\left(v+0.999v^2+0.999^2v^3\right)$$

$$+70+5\left(0.999v+0.999^2v^2\right)+30 \quad @3\%$$

$$2.91061P=141.51804+79.55307+30$$

$$P=86.26$$

[3]

Note that the question has made no reference to lapses, so we have ignored them here (although in practice an allowance for lapses would be made).

(ii)(a) ***Asset share***

The premium of 86.26 has just been received and the expenses of 70 have just been paid (assuming that the actual expense experience was the same as the best estimate). So the asset share is 16.26. [1]

Note that we would often have a negative asset share at the outset of the policy.

(ii)(b) ***Supervisory reserve (best estimate basis)***

$$V=50,080\times0.001\left(v+0.999v^2+0.999^2v^3\right)$$

$$+5\left(0.999v+0.999^2v^2\right)-P\left(0.999v+0.999^2v^2\right) \quad @3\%$$

$$V=141.51804+9.55307-164.80961$$

$$V=-13.74$$

[3]

Note that the reserve is negative as is often the case when calculating a best estimate reserve for a term assurance.

(ii)(c) ***Supervisory reserve (prudent basis)***

$$V = 50,090 \times 0.0013\left(v + 0.9987v^2 + 0.9987^2 v^3\right)$$

$$+6\left(0.9987v + 0.9987^2 v^2\right) - P\left(0.9987v + 0.9987^2 v^2\right) \quad @2\%$$

$$V = 187.54903 + 11.62673 - 167.15368$$

$$V = 32.02$$

[3]

Note that the reserve is positive as is usually the case when calculating a prudent reserve.

(ii)(d) ***Supervisory reserve (best estimate basis) plus solvency capital***

The best estimate reserves are -13.74 as calculated earlier.

The solvency capital requirement is:

$$SCR = 0.00091\left(50,000 - \left(-13.74\right)\right)$$

$$SCR = 45.51$$

[1]

So the total solvency requirement is 31.77 (45.51 – 13.74). [1]

(iii) ***Comments on results***

When the company writes this policy its assets increase by 16.26 (*ie* the asset share) and its reserves *decrease* by 13.74 if we use best estimate assumptions. So the surplus of the company (assets over liabilities) *increases* by 30 due to writing this policy. So if we calculate reserves on a best estimate basis (perhaps for accounting or internal management purposes) we can see that a profit of 30 occurs at outset (which is exactly the profit we priced for). [1]

However, the situation is quite different if we calculate reserves on a prudent basis. When the company writes this policy its assets increase by 16.26 (*ie* the asset share) and its reserves *increase* by 32.02. So the surplus of the company (assets over liabilities) *decreases* by 15.76 due to writing this policy. The company now has new business strain, *ie* the premium of 86.26 is not enough to cover the initial reserves of 32.02 and the initial expenses of 70. [1]

The total solvency requirement is approximately 32 under both the prudent reserving approach and the best estimate plus solvency capital approach (*of course we cheated in our choice of basis to make sure that this was the case!*). So both approaches give the same level of protection to the policyholders (they both require that the company sets aside an extra 45.5 over and above the best estimate cost of paying the liabilities) and have the same new business strain. [1]

[Total 3]

Solution 4.18

Compared to active valuation approaches, passive valuation approaches:

\+ tend to be more straightforward to implement [½]

\+ tend to involve less subjectivity, … [½]

… *eg* a net premium valuation is relatively insensitive to the choice of valuation basis [½]

\+ tend to result in relatively stable emergence of accounting profit [½]

\+ may be less likely to be subject to procyclicality and systemic risk: [½]

- a passive valuation of assets (such as historic book value) would be little affected by volatile asset prices [½]
- an active approach (such as market value) may result in the need to sell risky assets after a fall in prices, which could lead to further price falls [½]

– are at risk of becoming out of date, … [½]

… and hence management might fail to take appropriate actions in time; … [½]

… in particular, they might fail to take account of important trends, … [½]

… such as increasing mortality rates due to an epidemic … [½]

… or increasing inflation of expenses [½]

– may provide a false sense of security when the reality is that market conditions have changed significantly [½]

– tend to be less informative in terms of understanding the impact of market conditions on the ability of the company to meet its obligations ... [½]

… particularly in relation to financial guarantees and options … [½]

… although it is unlikely that a term assurance policy would include any financial options and guarantees, ... [½]

… and it is unlikely to be exposed to the equity market … [½]

… although it may be exposed to price volatility if it holds corporate bonds. [½]
[Maximum 6]

Solution 4.19

(i) ***Appropriate matching bonds***

The annuities are level, and all three of the bonds are fixed interest, so they all provide a good match by nature. [½]

Immediate annuity payments will be highest in the short term (when the majority of policyholders are still alive) but will also include some very long term payments … [½]

… so all three of the bonds should be appropriate to match the longer term payments … [½]

… but bonds with a range of short and medium terms will also be required. [½]

The yield margin between the government and corporate bonds reflects the higher risk of default … [½]

… and lower liquidity of the corporate bonds. [½]

The government bonds should have the lowest risk of default, … [½]

… so these may be the preferred option, especially if the insurer is risk-averse. [½]

The low grade bonds have the highest risk of default, … [½]

… so these may be deemed inappropriate. [½]
The high grade bonds should have a more acceptable level of default risk, … [½]

… and the greater return provided by corporate bonds may make these appealing enough to choose over the government bonds. [½]

If the insurer has matched its assets and liabilities (with bonds with a variety) of terms, then it would not be expecting to sell the bonds before maturity, and so liquidity is not an essential feature of the assets. [½]

The government bonds should be the most marketable / liquid. [½]

The large issue of low grade company bonds should also be fairly marketable / liquid. [½]

However, the small issue of small, private company bonds are likely to be considerably less marketable / liquid, … [½]

… and so a significant part of their yield will be to compensate for this illiquidity. [½]

As liquidity is a feature that is not needed by this insurer if it is well matched, these bonds may therefore be appropriate, … [½]

… as the insurer will be able to benefit from the higher yield without taking on a significant level of risk. [½]

However, if the insurer only invests in these three long-term bonds, then it will need to sell some of the bonds before maturity to pay benefits in the early years …

… so at least some of assets should be held in the more marketable and liquid government bonds. [½]

[Maximum 6]

(ii) ***How the choice of bonds would affect the discount rate used for the liabilities***

In a market-consistent valuation, the discount rate would usually be the risk-free rate obtainable on government bonds regardless of the choice of assets. [½]

However, an illiquidity premium can sometimes be included in the discount rate used for the liabilities to take credit for the illiquidity premium in the yield on the assets held. [½]

A higher discount rate will lead to a lower value of the liabilities, … [½]

… and so a better solvency position. [½]

If the insurer has chosen to hold the government bonds, it will not be able to include an illiquidity premium in its discount rate. [½]

If the insurer has chosen to hold either of the corporate bonds, then it may be able to include an illiquidity premium, … [½]

… if this is permitted by regulation / legislation. [½]

It is only generally appropriate to include an illiquidity premium for long-term, predictable liabilities … [½]

… which will be the case here if the insurer has a large enough portfolio to remove random fluctuations from the experience. [½]

The corporate bonds have similar yields overall, however, they are made up quite differently: [½]

- the multinational company's bonds have a high risk of default, but are very marketable / liquid, … [½]

- … so the majority of the yield margin (above the government bond yield) will reflect the default risk [½]

- the small private company's bonds have a lower risk of default, but are very unmarketable / illiquid, … [½]

  … so the majority of the yield margin (above the government bond yield) will reflect the illiquidity risk. [½]

Therefore, if the insurer held the multinational company's bonds, then the scope for including an illiquidity premium would be small, … [½]

… whereas if the insurer held the small private company's bonds, then a significant allowance may be made in the discount rate for illiquidity. [½]

[Maximum 4]

Question 5.18

Describe the various ways in which a life insurance company can help manage its capital position using reinsurance. [7]

Solution 5.18

Contingent loan

This approach makes use of the future profits contained in a block of new or existing business. [½]

The reinsurer provides the insurer with a cash loan. [½]
In return, the insurer will repay the loan to the reinsurer over a number of years. [½]

The repayments are contingent on the profits emerging from the business, and will not be paid if the profits do not materialise. [½]

The assets in the company's supervisory balance sheet will be increased by the amount of the loan. [½]

However, in some regulatory regimes the future loan repayments will not be included in the liability value shown in the balance sheet. [½]

The net effect is then to increase the value of the free assets in the company's balance sheet, so increasing capital. [½]

However, this form of financial reinsurance is not effective under accounting or supervisory regimes where credit can already be taken for the future profits and/or where a realistic liability has to be held in respect of the loan repayments. [1]

Risk premium reinsurance

Risk premium reinsurance can be used to reduce new business strain. [½]

The reinsurer provides a "loan" to the insurer in the form of reinsurance commission based on the volume of business reinsured. [½]

The loan repayments are spread over a number of years as additions to the reinsurance premiums. [½]

The reinsurer takes into account the expected lapse experience of the portfolio in determining the loan repayments. [½]

So, in a similar way to the contingent loan, the assets are increased by the reinsurance commission, but the liabilities may not need to increase to cover the additional reinsurance premiums. [½]

Again, this form of financial reinsurance is not effective under accounting or supervisory regimes where a realistic liability has to be held in respect of the loan repayments (*ie* the additional reinsurance premiums). [½]

Original terms reinsurance

Original terms reinsurance will reduce new business strain on individual policies as they are sold. [½]

A quota share basis will usually be used as this means that the benefits of the reinsurance will apply to all contracts (both big and small). [½]

The large initial commission will enhance the company's free assets, by capitalising the future expense loadings that the insurer is passing to the reinsurer through the reinsurance premiums. [1]

Further reduction in strain may be achieved if the reduction in net reserves exceeds the reinsurance premium, though the extent of this will depend on regulation. [½]

[Maximum 7]

Question 6.18

A life insurance company sells immediate annuities to impaired lives with low life expectancy. The annuities increase in line with an index of prices. The company believes that the best matching assets are index-linked bonds with a range of terms up to six years.

(i) Outline the factors that affect whether the insurer would mismatch its assets and liabilities. [7]

(ii) Describe what is meant by an "illiquidity premium" and discuss whether it is appropriate to allow for an illiquidity premium in the discount rate to value the annuity liabilities. [6]

[Total 13]

Solution 6.18

(i) ***Factors that affect the extent of mismatching***

The insurer will be *forced* to mismatch its liabilities: [½]

- as the term of the annuities is not known with certainty [½]
- if index-linked bonds of the right duration do not exist / are not available [½]
- if the index-linked bonds available are not linked to the same price index [½]
- if there is a lag in the index used for the bonds [½]
- if regulation specifies:
  - certain assets that the insurer is *required* to hold [½]
  - certain bonds that the insurer is not permitted to hold. [½]

In addition, the insurer may *choose* to mismatch its liabilities if: [½]

- it has a sufficient level of free assets [½]
- regulation does not prevent mismatching, *eg*: [½]
  - by currency [½]
  - by imposing onerous requirements to hold mismatching reserves [½]
- this does not lead to excessive solvency capital requirements [½]
- the proposed alternative assets:
  - are available [½]
  - provide a sufficiently high expected return to justify the extra risk taken [½]
  - are sufficiently liquid [½]
  - do not need a level of expertise above that of the insurer [½]
  - do not have prohibitively high dealing expenses or high taxes [½]
- its attitude to risk permits such a strategy, which may depend on: [½]
  - the risk management tools it has in place, *eg* reinsurance [½]
  - its need for diversification. [½]

[Maximum 7]

(ii) ***Illiquidity premium and the appropriateness of allowing for an illiquidity premium in the discount rate***

Illiquidity premium

Corporate bonds typically have a higher yield than risk-free (*eg* government) bonds, … [½]

… where this reflects both the greater default risk … [½]

… and the relative illiquidity of such assets. [½]

The latter of these contributes the illiquidity premium to the yield. [½]

An illiquidity premium can sometimes be included in the discount rate used to value the liabilities to take credit for the illiquidity premium in the yield on the assets held. [½]

A higher discount rate will lead to a lower value of the liabilities, … [½]

… and so a better solvency position. [½]

Appropriateness of allowing an illiquidity premium in the discount rate

The insurer would only be able to include an illiquidity premium to the extent that it holds corporate bonds to back its liabilities. [½]

If index-linked corporate bonds do not exist or are not available, then it would not be possible to include an illiquidity premium. [½]

Equally, if the insurer deems that the default risk of holding corporate bonds is too great, then an illiquidity premium will not be an option. [½]

Assuming that corporate bonds are held, it is only generally appropriate to include an illiquidity premium for long-term, predictable liabilities … [½]

… for which matching assets can be held to maturity. [½]

Provided the insurer has a large enough portfolio of liabilities so that the term is broadly known, … [½]

… then the liabilities may be predictable enough to justify the inclusion of an illiquidity premium ... [½]

… as the insurer can hold the bonds to maturity so will not be exposed to changes in their spread. [½]

However, the market for impaired life annuities for people with very low life expectancy may not be large enough to obtain a sufficiently large portfolio to remove the impact of random fluctuations. [½]

The term of the liabilities (up to six years) is also probably not long enough to justify the use of the approach, ... [½]

… because the choice of the discount rate has little impact when discounting over a short period. [½]

Overall, whether an illiquidity premium can be included is likely to be dictated by the regulatory regime in place, … [½]

… which would also specify how and when it can be used. [½]

[Maximum 6]