

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

13 September 2018 (am)

CA2: Model Documentation, Analysis and Reporting

Paper 2

Time allowed: 3 hours + 15 minutes reading time

INSTRUCTIONS TO THE CANDIDATE

1. You have 15 minutes reading time at the start of the examination in which to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You then have 3 hours to complete the paper.
2. You must write your summary from the beginning and not use an imported e-template.
3. At the end of the examination you have 5 minutes to upload your submission.

Your file names must include your ARN, the name of the document and the paper sat (e.g. 9000000-Summary-Paper1) and each file should contain your ARN as a header or footer.

Please note that the content of this booklet is confidential and students are not to discuss or reveal the contents under any circumstances nor are they to be used in a further attempt at the exam.

If you encounter any issues during the examination please contact Examinations team
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Exam requirements

1. Read the background document, which describes the scenarios that have been modelled and documented for this project.
2. Read the audit trail which has been written by your colleague, another actuarial student, for the calculations that they performed. This will assist you in following and understanding the calculations performed in the Excel model provided.

You are not required to add to or amend the audit trail.

You should assume that your colleague's calculations have been checked and are correct.

3. Expand the spreadsheet model to produce the required additional calculations for the proposed change in regulations. You should ensure that the additional work you undertake on the spreadsheet contains appropriate self-checks and you should not overwrite the existing calculations. The model should include the following:
 - i. An updated calculation of the profitability of each sample policy, and the overall average profitability of the Simple Saver business, based on the updated exit charges, and
 - ii. A determination of what the fund charge would need to be such that the expected profitability of the Simple Saver business, after the change in exit charges, will be the same as it was before the change in exit charges.

[9]

4. Construct, for each of the following, a suitable chart to illustrate the profitability of the product:
 - i. The total discounted profit, expressed as a percentage of the annual premium, for a \$100 per month policy for terms 5, 10 and 15 years respectively (after the changes to both the exit charges and fund charge have been made).
 - ii. The total discounted profit, expressed as a percentage of the annual premium, for a policy with a term of 10 years and a monthly premium of \$50, \$100, and \$200 respectively (after the changes to both the exit charges and fund charge have been made).
 - iii. The total (undiscounted) profit earned in \$'s each year for a policy with a term of 10 years, and a monthly premium of \$100 per month over the duration of the policy, and the accumulated profit in \$'s each year over the duration of the same policy (after the changes to both the exit charges and fund charge have been made).
 - iv. The impact of the change in regulation on the total discounted profit amount, as well as the average discounted profitability of the Simple Saver product (expressed as a percentage of the total annual premium) based on the expected mix of business. (You should ignore the impact of adjusting the fund charge.)

[8]

[Sub-total 17]

Prepare a summary document of around five to seven pages, capturing the main features and results of the work done by you and your colleague. You can assume that the summary is being prepared for your boss, a senior actuary, who will present the work to the Marketing Actuary.

Your summary should include the following:

- purpose of the project, data, method and assumptions used by you and your colleague
- results, including relevant tables and charts
- commentary on the results
- key conclusions
- suggested next steps

Commentary on the results should cover, but not be limited to:

- analytical comments on each stage of the results, including explaining patterns in the results and any unusual features.
- an explanation of the differences between the results under the various scenarios modelled.

Next steps need to be specific to the project, with some mention of why each is a valid next step.

The summary should cover the full scope of the project, including the current approach which was modelled in the spreadsheet provided.

You are not required to add to or amend the audit trail.

Marks available for the summary:

Methodology (including purpose, data, method and assumptions)	[25]
Results, including charts	[9]
Commentary on results and conclusions	[19]
Next steps	[20]
Drafting	[10]
	[Sub-total 83]
	[Total 100]

Background

You are an actuarial student working in the pricing team at Sunset Life, a life insurance company specialising in pension investment products. Another member of the pricing team has been working with your boss, the Pricing Actuary, on a new pension investment product called the ‘Simple Saver’.

The Simple Saver product allows the policyholder to invest monthly premiums into an individual fund which accumulates up to the date of their retirement. At retirement the policyholder can use the accumulated fund to provide an income. Policyholders are generally expected to keep their funds invested until retirement to maximise their potential retirement income. However, some policyholders withdraw their fund prior to their retirement date either by choosing to retire early, or by transferring their accumulated fund to another insurer’s pension product. To deter early withdrawal, pension regulations allow life insurance companies to deduct a charge from policyholders’ funds in the event of withdrawing money early.

The income that Sunset Life receives on the Simple Saver comes from three types of charge which are:

- a premium based charge – deducted from each premium before it is invested into the policyholder’s fund, and expressed as a percentage of the premium.
- a fund based charge – deducted from the policyholder’s fund at the end of each month, and expressed as a percentage of the fund value.
- an early exit charge – deducted from the policyholder’s fund on withdrawal prior to retirement, and expressed as a percentage of the fund value at the date of withdrawal. The exit charge will vary depending on the number of years between the date of withdrawal and the policyholder’s retirement date. No early exit charge applies on death of the policyholder prior to retirement.

Sunset Life incur costs in the set up and ongoing maintenance of each policy.

You have, up until now, not been involved in the development of this new product.

Product Specification of New Product: Simple Saver

The Marketing Actuary has given you the product specification for the new product. This contains the following details:

Premiums The policyholder invests a level premium each month up to retirement.

Premium charge

Monthly Premium Band	Charge (% of premium)
less than \$100	3%
\$100 - \$200	1%
more than \$200	0%

Fund charge 1% of fund value p.a., deducted as 1/12% of the fund value at the end of each month.

Exit charge

Years before retirement date	Charge (% of fund value at date of exit)
0-1	0%
2-4	2%
5-6	3%
7-9	4%
10+	5%

There are no other charges applicable to the policy.

Pricing Basis

Your boss has given you the proposed pricing basis for determining the expected profitability of the contract:

Initial expense	\$200 per policy
Recurring expenses	\$20 per policy per year, deducted monthly
Exit rate	5% per year
Mortality rate	0.5% per year at all ages
Fund Investment Growth	3% per year
Discount rate	5% per year
Expense inflation	0.6% per year, applied monthly

Profitability Modelling

The pricing model is used to calculate the profitability for nine ‘sample’ policies. The sample policies are made up of a combination of:

- i. premium sizes (\$50, \$100 and \$200); and
- ii. product terms (5, 10 and 15 years).

The sample policies are representative of the business that Sunset Life expects to sell for the Simple Saver product.

Your colleague has built a pricing model, which is included in the attached excel file. This has been produced to estimate the profitability of the new product. This model calculates the profitability of each sample product and the average profitability, both expressed as a percentage of the annual premium.

The Head of Sales has estimated that sales, of the Simple Saver Product, in the next year will total \$1,000,000 of annual premium. This is expected to be spread evenly across the range of premiums and terms.

Government changes

Following concerns raised by consumers and the financial press about the level of exit charges on pension products, the Government has just announced that it is changing the regulations governing these products. The regulations will introduce a maximum charge that can be levied on early exit prior to their retirement date. The changes are intended to protect consumers from the impact of excessive charges on exit prior to retirement.

Under the new regime insurance companies may not impose an exit charge on policyholders who withdraw their funds within four years of their retirement date. If the policyholder withdraws more than four years early the exit charge cannot exceed 1% of the fund value at the date of exit.

Your boss has expressed concerns about the negative impact of these changes on the profitability of the Simple Saver contract. He would like to consider amending the fund charges to offset the impact of the early exit charges. As your colleague working on the new product is away on leave, your boss has asked you to assess the financial impact of these new regulations as follows:

- i. Recalculate the profitability for each of the nine sample policies, and the average profitability, based on the updated exit charges (assuming the maximum allowable charge is levied).
- ii. Determine the amended fund charge such that the expected profitability of the Simple Saver business over the next year, allowing for the new exit charge, will be the same as it was before the change in exit charges. Include these figures in the summary.
- iii. Produce charts to illustrate the variation in total discounted profit between policies of different premiums, and different terms, as outlined in the exam requirements.
- iv. Produce a chart illustrating both the annual (undiscounted) profit and accumulated profit over time, for a 10-year policy with a premium of \$100 per month (after allowing for both the exit charges and fund charge changes).

Finally, your boss needs you to prepare a summary document covering all elements of the work (both the original work your colleague completed and the additional modelling you are undertaking).

Your summary should include the following:

- purpose of the project, data, method and assumptions used by you and your colleague
- results, including charts
- commentary on the results and key conclusions
- suggested next steps

You are not expected to update the audit trail to include the additional modelling you undertake, but the methodology of the additional modelling and your results should be included in the summary.

Audit trail

The following audit trail should be read alongside the model provided.

Objective

This spreadsheet models the new pensions saving product. It projects the cashflows of the product, including premiums, expenses, charges, and fund values. In particular, it

- Projects the probability that a policy remains active, taking into account mortality and exits prior to retirement.
- Projects the build-up of the fund balance of a typical policy.
- Combines the policy probability projection and fund projection to determine profit under a variety of premium and term scenarios.
- Uses projected sales figures to determine an overall expected profit figure for the new product.

Parameters worksheet

This worksheet details the inputs used in the projections. All input cells have been given range names, which are stated in red to the right of the input.

Several data items are required in order to perform the projections.

The Marketing Actuary provided:

- The premium based charge
- the annual fund charge
- the charge applied on early retirement.

The Pricing Actuary provided:

- expected investment growth
- appropriate discount rate for pricing purposes
- initial expenses
- recurring expenses
- mortality rate
- expense inflation.

It also contains the three premiums (\$50, \$100, \$200 per month) and terms (5, 10 and 15 years) used for the sample scenarios. These have been labelled as Low, Medium and High, to allow them to be parameterised throughout the model.

The allocated premium after the premium charge is calculated at the bottom of this section. This is equal to the premium multiplied by $(1 - \text{premium charge})$ for each premium size.

The Head of Sales provided:

The total expected sales figure for the Simple Saver Product for the coming year.

Assumptions

The following assumptions are applied to the projections:

- Premiums do not escalate, and remain level over time.

- The simplified pricing basis (including a flat mortality rate) is appropriate for the purposes of this investigation.
- Exits and mortality rates apply uniformly over the course of the year, and both are applied to the population at the start of each month.
- The ongoing expense applies monthly, from the first month of the policy.
- The fund charge applies to the fund value at the end of each month.
- Sales take place on the first day of the year, and profit figure is given as at that date.

Policy Projection worksheet

This worksheet calculates the probability of a policy being active after the impact of decrements.

- The first two columns are duration in months, and years.
- The probability of the policy being active at the start of the month is 1 for the first month. Thereafter, it is determined as the probability of it being active at the start of the previous month, less the probability of death, less the probability of exit.
- Deaths are calculated as the probability of a policy being active at the start of the month, multiplied by $qx/12$.
- Exits are calculated as the probability of a policy being active at the start of the month, multiplied by $ex/12$.
- The projection is completed for 20 years, and as exit rates do not depend on term, this projection can be used for a policy of any term.

Checks:

- The probability of death is lower than the probability of exit, as the exit rate is higher than the mortality rate.
- The probability of a policy being active starts at one, and decreases steadily over time. The figure at the start of year 2 is 0.946, which is close to the $1 - 0.5\% - 5\% = 0.945$ if simple subtraction was used.

Fund Projection worksheet

This sheet projects the fund value over time for a regular investment of \$1 per month. Note that the \$1 is the amount that actually gets invested in the fund, and is after the premium charge is taken off. This enables this one fund sheet to be used for any premium size – the fund value at a point in time is the value from this sheet, multiplied by the investment after the premium charge is deducted.

- Column A and B shows the term in months (A) and years (B).
- The fund at the start of month 1 is 1. Thereafter, the fund at the start of the month is equal to the fund at the end of the previous month, plus the \$1 premium.
- Investment income is the monthly investment return (calculated as $(\text{Fund value} \times i/12)$) applied to the fund value at the start of the month.
- The monthly fund charge of 1% per annum or $1/12\%$ per month is applied to the sum of the fund at the start and the monthly investment return.

- The fund at the end of the month is then the fund at the start of the month, plus the investment income, less the fund charge.
- Finally, expenses are included in column G. This column shows initial expenses, which occur at the start of month 1 and recurring expenses by adding these items together. Recurring expenses are inflated by applying the monthly inflation rate as follows:

$$\text{Recurring expense in month } n = \text{recurring expense}/12 * (1 + \text{inflation}/12) ^ (n-1)$$

Note that all factors applied to the fund projection are multiplicative.

Checks:

- All fund related values increase steadily over time.
- Expenses are high in year 1 due to the initial expense, and recurring expenses increase steadily with inflation, as expected.

Product Projection worksheet

This sheet calculates the profit and the discounted profit under various premium and term scenarios.

Column A and B displays the term in months and years.

Columns C to G include the calculations for a policy with term 5 years and monthly contributions of \$50 per month. For columns C to F, there is an IF statement to determine whether the term is less than or equal to the overall policy term. Where this is true, the following calculations are completed. Where this is false, a nil value is returned.

- Column C is the Premium charge. This is calculated as premium multiplied by the premium charge percentage. The premium charge percentage is looked up from the table on the parameters sheet. This is multiplied by the probability of the policy being active at that term (obtained from the Policy Projection sheet).
- Column D is the Fund charge. This is calculated as the fund charge in the fund projection for that term multiplied by the allocated premium in the scenario. This is multiplied by the probability of the policy being active.
- Column E is the exit charge which applies to policies that are assumed to be leaving before retirement. This is calculated in two parts:
Firstly, we have the probability of the policy having an exit charge. This is obtained from the probability of an exit from the Policy Projection sheet for that particular term.

Secondly, we have the charge that would apply if the policyholder did exit the policy. This is calculated as the fund value at the point of exit i.e. at that term (this is from the fund projection) multiplied by premium size multiplied by the exit percentage. The exit percentage used is the exit charge applicable from the input table depending on the remaining term, which is calculated as the length of the policy minus the policy year. The fund value is taken as the value at the end of the month of exit.

These two parts are multiplied together to obtain the total exit charge for each month.

- Column F is monthly profit, which adds the premium, fund and exit charge together and subtracts the expenses multiplied by the probability of the policy being active (from the Policy Projection sheet).
- An IF statement was also included in Column G. In this case, a check is completed to see the term is greater than the overall policy term. Where this is true, a nil value is returned. Otherwise, the discounted profit at time $t = (\text{discounted profit at time } t+1 \text{ plus profit in month } t) / (1 + i/12)$. A recursive function is used to determine the profit at the inception of the policy.

The interest rate used is the discount rate from the pricing basis.

The above columns are repeated for each combination of three premiums (\$50, \$100, and \$200 per month) and three terms (5, 10, and 15 years). The additional eight combinations can be found in columns H to AU, with labels in row 4 indicating which combination is being used for each set of columns.

Profit Summary worksheet

This sheet collates the discounted profit figures from the nine scenarios, and calculates the total profit expected from the year's sales.

The first table in cells in B7 to D9 shows the nine scenarios, and links to the Product Projection sheet to pick up the discounted profit for each scenario at the start of the contract, divided by the annual premium for that scenario.

The average discounted profit is calculated as the unweighted average of the discounted profit for the nine sample policies.

This is then multiplied by the total projected sales figure to return the total expected profit for the product for the next year.

END OF PAPER