

# **Institute of Actuaries of India**

## **Subject CP2A – Actuarial Modelling (Paper A)**

### **November 2020 Examination**

## **INDICATIVE SOLUTION**

#### **Introduction**

The indicative solution has been written by the Examiners with the aim of helping candidates. The solutions given are only indicative. It is realized that there could be other points as valid answers and examiner have given credit for any alternative approach or interpretation which they consider to be reasonable

## Audit trail

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### Objective

The purpose of the spreadsheet model is to do the following projections under scenario A and B:

- Projection of sales of numbers of policies for both single premium and regular premium policies (upto the year 2028), for both offline and online distribution channel, based on historic sales data under three different projection approaches.
- Projection of the annual sales revenue under different approaches, using given premium information.
- Determination of the year in which *annual* sales revenue from online sales is expected to exceed that from offline sales.

Scenario A: Include Arogya (19) policies in the projection

Scenario B: Exclude Arogya (19) policies in the projection

*The rest of the document describes the content and workings under each tab of the spreadsheet model and assumptions made in the model working:*

### Historic data tab:

This worksheet includes the raw sales data provided, which comprises numbers of policies sold for each of the four class of policies (SP-online, SP- offline, RP – Online, RP – offline) from year 2014 to 2019 inclusive.

*A quick check by eye suggests that there are no data items missing or materially mis-stated.*

### Assumptions:

- The historic sales data provided is correct.
- Historic observed trends in policies sales over the period 2014 to 2019 will continue.
- Sales of the AROGYA (19) policies were split between offline and online in the same proportions as all other policies sold in 2019.
- Sales of the AROGYA (19) policies occurred uniformly over the twelve months.
- There are no distortions in the historic data other than as described for the AROGYA (19) policies.
- No other such material distortions to sales will occur in the future projection period.
- No other distribution channel will be introduced in the future projection period.
- There are no other impacts on premium size over the projection period

### Projected sales numbers tab:

**In this worksheet the historic data is projected forwards to year 2028 using the three different suggested approaches.**

Each of the following tables can be found by scrolling down through the worksheet:

**Table 1:** The historic data is referenced from the “Historic data” worksheet. Let  $n_i$  denote the number of sales of a class in year  $i$  ( $i = 2014$  to  $2019$ ), as shown in this table.

A chart of this data has been produced to the right of this table (one line for each of the four classes of policies).

*The line chart confirms that the data seems reasonably complete and valid, with each of the lines being smooth.*

**Table 2:** This table determines  $x_i$  = the % change (year on year) of sales numbers, for  $i$  = 2015 to 2019, for each of the four classes.

Each  $x_i$  is calculated as  $\{n_i / n_{i-1}\} - 1$  (from the table 1).

In column J, the mean of all  $x_i$  (from  $i$  = 2014 to 2019) is calculated for each of the four classes, using the function AVERAGE. Let these means be denoted as  $X$  in this audit trail.

An auto-check is included in column K: this checks that a negative average % change corresponds to an overall reduction in sales over the historic period, and a positive mean to an overall increase.

**Table 3:** This table determines  $y_i$  = the ratio of year on year % changes, for  $i$  = 2016 to 2019, for each of the four classes.

Each  $y_i$  is calculated as  $x_i / x_{i-1}$  (from the table 2).

In column J, the mean of all  $y_i$  (from  $i$  = 2016 to 2019) is calculated for each of the four classes, using the function AVERAGE. Let these means be denoted  $Y$  in this audit trail.

**Table 4:** This table contains the projection factors required for each of the three proposed approaches, and for each of the four classes. These factors are referenced from Table 2 and 3 as follows:

For Approach 1, the factor is  $x_{2019}$  (from Table 2).

For Approach 2, the factor is  $X$  (from Table 2).

For Approach 3, the factor is  $Y$  (from Table 3).

**Table 5:** This table contains the historic sales data (as per Table 1) and projects it forwards for each of the four classes, using **Approach 1** i.e. the future year on year % change is constant and at the same level as it was from 2018 to 2019.

This is done by calculating  $n_i = n_{i-1} * (1 + x_{2019})$  for  $i$  = 2020 to 2029.

In other words, the number of sales projected in a particular year is calculated as the number of sales in the previous year (previous column), multiplied by  $\{1 + \text{Approach 1 factor from Table 4}\}$ .

**Table 6:** This table contains the historic sales data (as per Table 1) and projects it forwards for each of the four classes, using **Approach 2** i.e. the future year on year % change is constant and at the same level as the mean of the % changes over the historic period.

This is done by calculating  $n_i = n_{i-1} * (1 + X)$  for  $i$  = 2020 to 2028.

In other words, the number of sales projected in a particular year is calculated as the number of sales in the previous year (previous column), multiplied by  $\{1 + \text{Approach 2 factor from Table 4}\}$ .

**Table 7:** This table contains the historic sales data (as per Table 1) and projects it forwards for each of the four classes, using **Approach 3** i.e. the future year on year % change varies, in line with patterns in the historic % changes.

This is done by calculating  $n_i = n_{i-1} * [M * (n_{i-1} / n_{i-2} - 1) + 1]$  where for  $i > 2019$ .

In other words, the number of sales projected in a particular year is calculated as the number of sales in the previous year (previous column), multiplied by  $(1 + \text{Approach 1 factor from Table 4 multiplied by } \{\text{Approach 3 factor from Table 4, to the power of } N\})$ .

**Table 8:** This table collects the chosen projections from the above tables. It is therefore the same as Table 7 (Approach 3) except for offline- RP policies, for which the projections are referenced from Table 5 (Approach 1).

Column S includes an auto-check that all projected sales numbers are positive for each of the approaches (Tables 5 to 8).

*It shows a problem with Offline RP for Approach 3, which helps to support the decision not to use this approach for that class.*

### **Approach 3 further check:**

Below Table 8 (row 69) can be found auto-checks that Approach 3 has been calculated correctly. The first and second order % changes are determined and there is an auto-check in column R which validates that the second order changes are constant (by checking that each of these changes is equal to the mean change across that type).

### **Projected sales charts tab:**

**In this worksheet three line charts are drawn showing the historic and projected sales numbers under the four classes, with one chart for each of the three projection approaches used.**

The data used for the charts are as per Tables 5, 6 and 7 respectively of the previous worksheet.

*The future projections are all reasonably smooth, which helps to validate the underlying projections.*

*Approach 1 illustrates projection trends which (as expected) are most consistent with those in the final historic year, e.g. online sales continuing to increase at a steady rate.*

*Approach 2 illustrates more extreme projections, particularly for online sales, which increase materially in future years. This is consistent with the fact that the approach taken uses historic average increase factors rather than the most recent, and that increases in online sales have been slowing down over recent years (so historic average increase is higher than most recent increase).*

*Approach 3 illustrates projections which level out more quickly, which is consistent with the use of second order differences. The deceleration of increases in digital sales is projected to continue, and hence these sales start to level out more.*

*The charts therefore suggest at a high level that the projection calculations have been performed correctly.*

### **Adjusted sales projections tab:**

**This worksheet repeats the sales number projections, but including an adjustment to allow for the potential distortion of high sales of the AROGYA (19) policies, by reversing these sales out of the 2019 historic data.**

It is a copy of the worksheet “Projected sales numbers” with the following changes:

Inserted 9 rows below the first row to make following changes:

- Total number of **AROGYA (19) policies** in first twelve months is input to cell C3.
- In cells C4 and C5 the percentages of total policies which are offline and online
- respectively are calculated from the table 1 in “Projected sales numbers” tab for the year 2019 (e.g.
- $\text{offline \%} = \text{offline} / \{\text{offline plus online number}\}$ ).
- The estimated proportion of total **AROGYA (19) policies** sales occurring in 2019 is input to cell C7

(input as 10/12, assuming sales are uniformly spread over the year and given that it was issued at the start of March).

In cells C8 and C9 the offline and online AROGYA (19) policies sold in 2019 are calculated as total AROGYA (19) policies sales \* proportion occurring in 2019\* offline/online proportion as applicable.

Table 1 is now the “Adjusted numbers of sales”, with the AROGYA (19) policies offline and online (from cells C8 and C9) being deducted from the relevant offline and online regular premium policies figures in year 2019 only.

All other Tables, projection calculations and checks are as for worksheet “Projected sales numbers”.

In cell L31 a further calculation has been inserted: the differences between the sets of Y with and without the AROGYA (19) policies adjustment have been determined. An auto-check has been included to check that the figures for offline and online SP policies are unaffected.

An additional auto-check has been included in cell L41, which checks that the total number of projected SP (offline and online) remains unaffected by the AROGYA (19) policies adjustment (i.e. the same projected total as for the unadjusted version).

### Projected sales in Rs. millions

**This worksheet projects the expected annual sales amount for year 2020 to 2028 and estimates the year at which online sales are expected to exceed offline.**

In the top left-hand corner of this worksheet, 2014 and 2019 average annual premium size for each of the class of policies.

The average annual growth rate ( $g$ ) for each of the four classes is then calculated (column E) as:  $[(\text{Price in 2019} / \text{Price in 2014})^{1 / (2019 - 2014)} - 1]$

In rows 13 to 16, the projected premium for each of the four types of policies is calculated as the premium in 2019 multiplied by  $(1 + g)^{(N - 2019)}$  where  $N$  is the projection year (from 2020 to 2028).

In rows 21 to 24, these premiums are multiplied by the numbers of policies sold (referenced from Table 8 of the “Projected sales numbers” tab) for each of the four classes and for each of the years 2020 to 2028. This determines the projected annual total premium for each type of policies.

Total revenues in each year for offline and online are then determined (i.e. RP plus SP), and in row 29 the % online (online / total online plus offline) is then calculated for each projection year to 2028. Denote this % as  $d_i$  for-year  $i$ .

The target minimum online proportion is input to cell N4 (coloured blue). Denote this % as  $t$ . For digital sales to exceed offline sales, input  $t = 50\%$ .

Row 30 contains a Y/N indicator (using IF statements, comparing the value of each  $d_i$  with  $t$ ), working on an annual revenue basis:

- $N$  means that the target online proportion has not yet been reached at the end of that year ( $d_i < t$ ).
- $Y$  means that the target online proportion has just been reached (and exceeded) at the end of that year ( $d_i > t$  and  $d_{i-1} < t$ ).
- A blank cell means that the target online proportion has already been reached at a prior year ( $d_i > t$  and  $d_{i-1} > t$ ).

The year in which annual digital sales are expected to have exceeded the minimum target percentage  $t$  must then equal  $i$ . This is captured in cell L7 (using HLOOKUP to identify the year corresponding to the only column in which “Y” appears in row 30).

Rows 34 to 47 contain the same calculations as above, but using the sales figures after adjustment for the **AROGYA (19) policies** (i.e. now taken from worksheet “Adjusted sales projections”).

An auto-check has been added in cell Q39 which checks that the total premium arising from sales of SP is the same as in the above tables, i.e. unaffected by the **AROGYA (19) policies**

The relevant year for the adjusted data is determined in cell L8.

### ***Reasonableness checks***

The results show the estimated revenue “crossover” points being in the years 2023/2024. This is consistent with the charts of projected sales numbers, which show the online and offline RP crossing at around that point (i.e. online sold being higher) for the chosen Approaches 1 and 3. Since sales revenue is dominated by RP (higher price per unit) this is consistent with the results obtained here, thus demonstrating the reasonableness of the calculation approach.

After the **AROGYA (19) policies** adjustment, online sales are expected to exceed offline sales earlier than for the unadjusted data. This makes sense because:

- RP have a higher weighting towards offline rather than online; SP are almost entirely online.
- Reducing the total number of RP in the projections will therefore have a relatively greater reducing impact on revenues from offline than on revenues from online.
- Hence online revenues are more likely to exceed offline earlier than otherwise.

### **Sales revenue charts**

**This worksheet summarises the annual sales revenue results from the previous two worksheets and produces related graphs:**

- Projected total offline sales revenue (RP plus SP) and total online sales revenue (RP and SP) in each year to 2028, with no adjustment for the **AROGYA (19) policies**.

This is presented as a stacked bar chart, so also shows total premium across all classes.

- projected total overall sales revenue (added across all classes) in each year to 2028, without and with adjustment for the **AROGYA (19) policies**. This is presented as a side by side bar chart.

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