

## **Subject CA2 2015 – specimen exam papers**

The specimen exam papers below show how the syllabus will be examined across the two parts of the CA2 exam from March 2015

- In Paper 1 you will build a model and provide a clear audit trail.
- In Paper 2 you will be given a model to analyse, interpret and summarise.

In this specimen exam (published September 2014), both parts of the paper use the same model. In future CA2 exams, each part of the exam will use a different model.

The marks shown on each paper are indicative of the balance of marks which will apply to each part. The marks for each exam will differ to reflect the precise details of each assignment.

**INSTITUTE AND FACULTY OF ACTUARIES**

**SPECIMEN EXAMINATION BOOKLET**

**2015**

**CA2: Model Documentation, Analysis and Reporting**

**Paper 2**

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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, a fellow actuarial student, on the calculations performed. Reference the calculations performed in the provided Excel workbook against the steps described in the audit trail.
3. Produce appropriate charts to summarise the calculations performed by your colleague, a fellow actuarial student. These charts should include:
  - Projected total physical and total digital annual sales revenue in each year to 2021, for each scenario.
  - Projected total overall annual sales revenue in each year to 2021, for each scenario.

In determining these charts you should assume that the colleague's calculations have been checked and found to be correct.

**[10 marks]**

4. Determine the year in which annual revenue from digital sales is first expected to exceed that from physical sales, for each scenario.

**[3 marks]**

5. Prepare a summary document of around five to six pages, capturing the main features and results. You can assume that the summary is being prepared for your boss, a senior actuary, who will present the work to ARMI tomorrow. Your summary should cover the following:
  - purpose of the project, data, approach and assumptions used
  - results, including charts
  - conclusions and suggested next steps

**You are not required to add to the audit trail.**

**Marks available for the summary:**

<b>Methodology (including purpose, data, approach and assumptions):</b>	<b>[15]</b>
<b>Results, including charts</b>	<b>[17]</b>
<b>Conclusions</b>	<b>[20]</b>
<b>Next steps</b>	<b>[20]</b>
<b>Drafting</b>	<b>[15]</b>
<b>Total marks for paper</b>	<b>[100]</b>

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## Background – Boss instructions to actuarial colleague

In the country of Actuaria, musical artists distribute their output to the general public in the form of albums (i.e. several tracks packaged together) and/or singles. Albums and singles are available in two different formats: physical (vinyl records and CDs) and digital (downloads).

You are an actuarial student working for a consultancy in Actuaria. The Actuarial Recorded Music Industry (ARMI) approached your boss, a qualified actuary, and asked whether it would be possible to construct a model which projects numbers of sales and sales revenue for the different formats for each year up to and including 2021. In particular it is interested in understanding when revenue from the sale of downloads might overtake that from physical sales.

In order to perform these projections and analysis, ARMI provided your boss with its data on the numbers of albums and singles sold in each of the two formats (physical and digital) in the calendar years 2007 to 2012 inclusive.

When providing the data, ARMI also pointed out that there was an unusual situation in 2012 which may need to be taken into account in the sales projections. One particular album, by a band called Yodelle, accounted for a very high proportion of the overall sales. The album (“Twenty-Twelve”) was launched at the start of March 2012. In its first twelve months of availability, it had sold a total of 7 million copies across the two formats. The relevant sales of this album were included in the data provided.

### Numbers of sales

Your boss suggested to one of your colleagues, also an actuarial student, three possible approaches by which the numbers of sales could be projected.

For each of the four classes of data (physical singles, physical albums, digital singles, digital albums), your colleague was asked to calculate the % change (year on year) of sales numbers for each of the past years for which this was possible. This % year on year change was defined as the *additional* increase (or decrease) rather than as the ratio of values. So for example, the % change from 100 to 105 should be expressed as 5% rather than 105%.

Each class was then projected forward assuming that:

**Approach 1:** the future year on year % change was constant, and at the same level as it was from 2011 to 2012.

**Approach 2:** the future year on year % change was constant, and at the same level as the arithmetic mean of the year on year % changes over the 2007–2012 data period.

**Approach 3:** the future year on year % change varies, in line with patterns in the historic % changes. More specifically, if  $\{x_i\}$  represents the set of historic % changes from year  $i - 1$  to year  $i$  (for  $i = 2008$  to 2012), then your colleague first needed to calculate the second order % changes in the form of ratios  $x_i / x_{i-1}$ . Your boss suggested that your colleague then take the arithmetic mean of these ratios and assume that the second order % changes stay at this level in future. This enabled your colleague to produce the first order % changes (i.e. the  $x_i$  for  $i > 2012$ ) and hence to project the future sales numbers.

Your boss asked your colleague to produce projections of the numbers of sales for each of the four data classes using each of these three approaches in turn. She requested your colleague to do this in the first instance ignoring any potential adjustment for the Yodelle album.

Although she felt that it was useful to present the client with the projections from each of the three approaches, having performed some high level preliminary analysis she decided that the most appropriate method is Approach 3 for all classes other than physical albums, for which Approach 1 appeared to be preferable. She asked your colleague to demonstrate that this decision is not unreasonable, and then to use these specified approaches for the rest of the analysis.

Before starting to consider the amounts of sales revenue, your boss asked the actuarial student to repeat the projections of sales numbers using the specified approaches (i.e. Approach 3, other than Approach 1 for physical albums). However, this time she wants the Yodelle album information removed from the data provided, in order to understand the potential impact of this possible distortion.

### **Sales revenue**

ARMI provided the following data on the prices of albums and singles in each format (figures in Actuarian dollars \$):

- Physical singles cost an average of \$3.00 each in 2007, but this had fallen to \$2.40 in 2012.
- Physical albums cost an average of \$10.00 each in 2007, but this had fallen to \$8.00 in 2012.
- Digital singles cost an average of \$1.00 each in 2007, but this had fallen to \$0.80 in 2012.
- Digital albums cost an average of \$10.00 each in 2007, but this had fallen to \$7.00 in 2012.

Annual inflation in Actuarial in the period 2007 to 2012 was broadly zero.

Your boss asked your colleague to use their projections of sales numbers and the above price information to estimate future annual sales revenues to 2021 for each of the four classes. She asked your colleague to assume that the reduction in prices continues at the same annual rate throughout the projection period.

The colleague performed the above sales revenue projections and analysis both ignoring and allowing for the Yodelle adjustment.

The projections were also repeated assuming that Yodelle album sales are excluded from the data, but now assuming that future prices stay at the 2012 levels.

The colleague completed the above calculations and drafted an audit trail. Your boss needs you to prepare a summary for her for when she returns to the office in three hours.

# Data

## Numbers of sales in millions

	Year	2007	2008	2009	2010	2011	2012
Physical:							
	Singles	14.6	8.4	4.8	3.0	2.1	1.6
	Albums	137.5	131.6	123.2	112.7	98.7	84.5
Digital:							
	Singles	52.5	79.5	113.4	145.5	166.7	176.5
	Albums	2.8	6.2	10.3	16.1	21.0	26.1

Source: Actuarian Recorded Music Industry (ARMI)

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# Audit trail

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

## Objective

The purpose of the spreadsheet is to complete the following calculations:

- Project forwards future sales numbers of music singles and albums (to the year 2021), each separately in physical and digital format, based on historic sales data and using three different projection approaches.
- Use these to project forward also the expected annual sales revenues from each format, using given price information.
- Analyse the effect on all projections of adjusting for one particularly high selling album in the most recent data year.
- Perform adjusted calculations using different assumed future price growth rates.

*NB: Input cells are shown in blue.*

## Historic data

This worksheet includes the raw data provided, which comprises numbers of sales of each of the four music formats (physical singles, physical albums, digital singles, digital albums) from 2007 to 2012 inclusive. This was provided by the Actuarial Recorded Music Industry.

*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 music sales over the period 2007 to 2012 will continue into the future.
- Sales of the Yodelle album were split between physical and digital in the same proportions as all other albums sold in 2012.
- Sales of the Yodelle album occurred uniformly over the twelve months.
- There are no distortions in the historic data other than as described for the Yodelle album.
- No other such material distortions to sales will occur in the future projection period.
- No other musical formats will be introduced in the future projection period.
- Other musical formats (box sets, mini-discs, cassettes, data stick, streaming services, ringtones etc.) are either included in the given data figures or are immaterial and therefore can be ignored.

- There are no other impacts on prices over the projection period, i.e. there is a stable economic situation and underlying inflation remains broadly zero.
- There are no impacts on future volumes as a result of assumed higher prices under the alternative scenario (i.e. prices and sales volumes are independent).

### Projected sales numbers

**In this worksheet the historic data is projected forwards to year 2021 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 previous worksheet. Let  $n_i$  denote the number of sales of a particular format in year  $i$  ( $i = 2007$  to  $2102$ ), 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 music formats).

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

**Table 2:** This table determines  $x_i$  = the % change (year on year) of sales numbers, for  $i = 2008$  to  $2012$ , for each of the four formats.

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

In column J, the mean of all  $x_i$  (from  $i = 2008$  to  $2012$ ) is calculated for each of the four formats in turn, 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  $i = 2009$  to  $2012$ , for each of the four formats.

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

In column J, the mean of all  $y_i$  (from  $i = 2009$  to  $2012$ ) is calculated for each of the four formats in turn, 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 formats. These factors are referenced from Tables 2 and 3 as follows:

For Approach 1, the factor is  $x_{2012}$  (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 formats, using **Approach 1** i.e. the future year on year % change is constant and at the same level as it was from 2011 to 2012.

This is done by calculating  $n_i = n_{i-1} * (1 + x_{2012})$  for  $i = 2013$  to 2021.

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 + 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 formats, 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  $i = 2013$  to 2021.

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 + 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 formats, 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  $n_i = n_{i-1} * (1 + x_{2012} * Y^N)$  where  $N = i - 2012$ , for  $i = 2013$  to 2021.

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 + Approach 1 factor from Table 4 multiplied by {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 physical albums, 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 physical albums for Approach 3, which helps to support the decision not to use this approach for that format.*

*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 format).

## Adjusted sales projections

**This worksheet repeats the sales number projections, but including an adjustment to allow for the potential distortion of high sales of the Yodelle album, by reversing these sales out of the 2012 historic data.**

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

Total number of Yodelle album sales in first twelve months is input to cell C3.

In cells C4 and C5 the percentages of total album sales which are physical and digital respectively are calculated from the table in “Projected sales numbers” for the year 2012 (e.g. physical % = physical number / {physical number plus digital number}).

The estimated proportion of total Yodelle album sales occurring in 2012 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 physical and digital Yodelle album sales occurring in 2012 are calculated as total Yodelle album sales  $\times$  proportion occurring in 2012  $\times$  physical/digital proportion respectively.

Table 1 is now the “Adjusted numbers of sales”, with the Yodelle physical and digital album sales (from cells C8 and C9) being deducted from the relevant physical and digital album figures in year 2012 only.

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

In cell L29 a further calculation has been inserted: the differences between the sets of Y with and without the Yodelle data adjustments have been determined. An auto-check has been included to check that the figures for physical and digital *singles* are unaffected.

An additional auto-check has been included in cell L41, which checks that the total number of projected *singles* (physical plus digital) remains unaffected by the Yodelle adjustment (i.e. the same projected total as for the unadjusted version).

## Projected sales \$m – Base

**This worksheet projects the expected annual sales revenue from 2012 to 2021 under the base price scenario.**

In the top left hand corner of this worksheet, 2007 and 2012 prices for each of the four music formats are input.

The average annual growth rate ( $g$ ) for each of the four formats is then calculated (column E) as:  $(\text{Price in 2012} / \text{Price in 2007})^{1 / (2012 - 2007)} - 1$

In rows 13 to 16, the projected price for each of the four music items is calculated as the price in 2012 multiplied by  $(1 + g)^{(N - 2012)}$  where  $N$  is the projection year (from 2013 to 2021).

In rows 21 to 24, these prices are multiplied by the numbers of items sold (referenced from Table 8 of the “Projected sales numbers” worksheet) for each of the four formats and for each of the years 2012 to 2021. This determines the projected annual sales revenues for each format.

Total revenues in each year for physical and digital are then determined (i.e. albums plus singles).

Rows 34 to 44 contain the same calculations as above but using the sales figures after adjusting for the Yodelle album. An auto-check has been added to cell Q39 which checks that the total revenue from the sales of singles is unchanged.

### **Projected sales \$m – Alt**

**This worksheet projects the expected annual sales revenue from 2012 to 2021 under the alternative price scenario, i.e. assuming no future growth in the prices per unit. It again estimates the year at which digital sales are expected to exceed physical.**

It is a copy of the worksheet “Projected sales \$m – Base” with the following amendments:

- Prices per unit are linked to the previous worksheet.
- Future annual growth rates are no longer calculated, but set to zero (cells E5 to E8).
- Some additional auto-checks have been included in column Q to ensure that the 2012 figures remain unchanged.

#### *Further reasonableness checks:*

- *Under the base scenario projected total annual sales revenue from physical formats is shown as reducing materially over time, which is reasonable due to both falling numbers of sales and reducing prices. Sales revenue from digital formats is broadly unchanged from year to year (a slight rise followed by a slight fall), which reflects the combined impact of increasing numbers of sales but reducing prices.*
- *Projected overall total annual sales revenue falls over time, which is consistent with the total of the above effects. As well as the contribution from falling prices, this pattern is also consistent with the gradual shift from physical to digital formats within the future projections, digital having lower prices (and thus revenue) per unit.*
- *Projected total annual sales revenue with the Yodelle adjustment is lower in all future years than without the adjustment, which is reasonable given that the adjustment removes material numbers of album sales from the data and hence from the future projections (i.e. it assumes such significant album releases do not reoccur in future years). However, the pattern of run-off is broadly unchanged – which is also reasonable as the historic trends continue to be projected forwards, just at a lower level.*
- *Projected total annual sales revenue under the alternative price scenario is higher in all future years than under the base price scenario, which is reasonable since the latter assumes that all prices fall in each year in future, whereas the alternative scenario holds prices level.*

**END OF PAPER**

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