The Actuarial Profession
making financial sense of the future

Project L12

Audit trail

Objective

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

- Projection of the gradual deterioration in quality of consignments of bananas, which are "downgraded" in accordance with a set of daily transition rates. These projections are first done for the phase of transportation from Producers to Depot, and then from the phase of transportation from Depot to Retailers.
- Calculation of expenses incurred during these phases and of the income received from the retailers.
- Net present value of all cashflows and determination of the price that can be paid per banana to the original producers in order to meet the distributor's profit criterion.
- Calculation of the internal rate of return achieved under the overall transaction.
- Alternative scenarios, including a "banana blight" shock incident impacting both banana volumes and transition rates, and a decision not to transport Grade C bananas.

Inputs

This worksheet contains the data and parameters provided in the Background information. It also uses them to perform some additional calculations as follows:

- Completion of the Scenario 1 transition rate matrix, with the transition rate from Grade X to Grade X being calculated as {1 – the sum of transition rates from Grade X to other lower Grades}.
- Calculation of an adjusted transition rate matrix for use in Scenario 2, under which the transition rates from Grade X to other lower Grades have been multiplied by the "transition rate adjustment factor" parameter. The formula for transition rate from Grade X to Grade X remains unchanged, though the amounts will now differ.
- Conversion of the annual discount rate to a daily discount rate, by taking the power of (1/365).
- Calculation of the ratio of the retail prices for different Grades of banana to the retail price for Grade A bananas. This will be used to determine an appropriate pattern of prices to be paid to the producers.

It has been assumed that:

- The transition rates provided are independent.
- Future inflation can be ignored, since it has been very low recently in Actuaria and the time period considered is relatively short.
- The ratio of prices by Grade of banana paid to the producers should be the same as the ratio of prices by Grade paid by the retailers.

Banana Projections 1

In this worksheet the number of bananas by Grade has been projected for each transportation phase using Scenario 1 information. The related expenses, payment from retailer and initial payment to producer have also been calculated.

In more detail:

From Producer to Depot

The first table takes the number of bananas that will be purchased from Producer X (from "Inputs") and then projects them, by Grade, over the 25 day transportation period from the plantation to the Depot.

During that time, the bananas will deteriorate in quality. This has been allowed for by using the numbers of bananas of various Grades from the previous day and applying the daily transition rate matrix as follows:

- Grade A bananas day x = Grade A bananas day x-1 multiplied by Transition rate A to A
- Grade B bananas day x = Grade B bananas day x-1 multiplied by Transition rate B to B *plus* Grade A bananas day x-1 multiplied by Transition rate A to B
- And similarly for Grades C and F.

In order to check that no bananas are "lost" from this calculation, a check is in place (see Row 16) that the total remains unchanged throughout the projection period.

Below this table of the projected numbers of bananas are calculations of:

Transport expenses:

- The number of boxes required is determined as the total number of bananas divided by the permitted number per box, then rounded **up** to the nearest integer (as cannot have partial boxes).
- The total daily transport expense is then the fixed daily cost plus {daily cost per box multiplied by number of boxes}.

Amount paid to producer:

- **NB** The amount paid to the producer per Grade A banana has been taken from the later "Pricing" sheet and will depend on completion of the goalseek calculations done there.
- The amounts paid per other Grades of banana have been determined by using the ratios of retail prices as per the "Inputs" worksheet.
- The total amount paid to the producer is determined by multiplying these prices per Grade by the initial number of bananas (by Grade) collected from the producer.

These projections and calculations are then all repeated for Producer Y, but for a shorter time period (15 days) to reflect the shorter journey.

From Depot to Retailers

Similar banana deterioration projections are then carried out for the second phase of transportation (see Rows 47 downwards), over the 20 days of shipping.

First, the total bananas received from both Producers X and Y are summed.

The bananas are then projected, by Grade, exactly as for the first transportation phase, including a check that the total remains unchanged.

Below this table of the projected number of bananas are calculations of:

Expenses:

- Calculated as for the first transportation phase, but with different inputs plus there are also now (fixed) sorting costs incurred at the Depot.

Income received:

- The amount received from the retailer is calculated as the number of bananas of a specific Grade as at the end of the 20 day shipping projection period, multiplied by the retail price for that Grade. This is then summed over Grades A to C.

For this worksheet it is assumed that:

- The number of bananas collected by BDS will be exactly as per their arrangements with the two producers.
- The bananas do not hang around in the Depot but are shipped immediately after arriving and sorting, i.e. there is no additional deterioration during that time.
- Grade F (rotten) bananas are identified during the sorting and are not included in the shipment to Cohortico. "Total shipped" is therefore the same as "Total received" other than the removal of all Grade F bananas.

Banana Projections 2

This worksheet is a copy of that for Scenario 1 with the following exceptions (highlighted in colour on the worksheet):

- The numbers of bananas received from the two producers have been multiplied by {1-banana blight % lost}.
- The transition rates for all phases of the transportation are now taken from the adjusted table (see "Inputs").

It has been assumed that:

- The banana blight impacts all Grades of banana and all transition rates equally, and in the same way for both plantations.

The accuracy of the copy of this worksheet can be tested by setting the "Inputs" parameters back to the same as the conditions under Scenario 1 (i.e. Banana blight % lost should be set to zero and Transition rate adjustment factor to 1) and checking that the calculations give the same results as for Scenario 1.

Banana Projections 3

This worksheet is a copy of that for Scenario 1 with the following exceptions (highlighted in colour on the worksheet):

- The numbers of Grade C bananas collected from Producer X and Producer Y have both been set to zero.
- The number of Grade C bananas shipped from the Depot to the retailer has been set to zero.

Pricing

This worksheet performs the cashflow, present value, pricing and internal rate of return (IRR) calculations for each of the different Scenarios.

Column A describes the type of cashflow in the order (by row) in which it occurs: payment for bananas purchased from producers, payment of expenses (sorting and transportation) and receipt of payment for bananas from retailers.

Column B gives the timing (in days) of each of those cashflows, with t=0 being the start of the process (i.e. collection from Producer X).

It has been assumed that:

- There is no delay at the Depot.
- The transportation expenses are incurred continuously through the periods for which they are incurred, which can be approximated using the mid-point of that period.
- Payment is made to the producers when the bananas are collected, and payment is received from the retailers as soon as the bananas are delivered to them.

Note that collecting bananas from Producer Y (and the start of that journey) must occur at time t=10 in order for the bananas to arrive at the Depot at the same time as those from Producer X, as required by BDS.

Columns D-F contain the cashflow and IRR calculations for Scenario 1.

Column D is the amount for each type of cashflow, taken from the "Banana Projections 1" worksheet. The transportation expenses are the daily expense multiplied by the number of days in transit for each particular journey. Cashflows out are shown as negatives (expenses, initial cost of bananas) and cashflows in as positives (received from sale of bananas to retailers).

Column E discounts these cashflows to time t=0 using the risk discount rate per day (from "Inputs") and the cashflow timings as per Column B.

These discounted values are summed to give Total Profit (Row 17), which is then compared with the stated profit criterion (Row 18) to give the "Additional profit" (Row 19) i.e. the excess of the actual profit received over the required profit criterion.

It has been assumed that:

- The given profit criterion is the value as at the start of the process, i.e. t=0.
- Tax can be ignored.
- There are no other costs or expenses other than those listed.
- All data provided is accurate.

In order to determine the price that can be paid to the producers per banana, the net present value profit must be set equal to the profit criterion.

This is done using goalseek:

- Set the Scenario 1 "Additional profit" (cell E19) to zero….
- …. by varying "Payment to producer per A banana" (cell B5).
- A check message indicates whether the goalseek needs to be rerun.

Once solved, the payments for Grade B and C bananas are also determined (using the ratios as per the retail price ratios calculated in "Inputs") – see Rows 25-27.

Column F discounts the cashflows in the same way as Column E, but this time using the "IRR per day" (cell F20) rather than the given risk discount rate. The IRR is determined using goalseek, by setting the "Total Profit" under the IRR discount rate (cell F17) to zero by varying "IRR per day" (cell F20). A check message indicates whether the goalseek needs to be rerun.

Similar calculations are performed for Scenario 2 in columns H-J, taking all cashflows now from "Banana Projections 2". There is no need to run the first goalseek in order to obtain banana prices for this scenario: the price per banana derived from Scenario 1 was automatically used in the underlying projections. The "Additional profit" in Row 19 now shows the additional profit (if positive) or loss (if negative) incurred as a result of Scenario 2, over and above the required profit criterion.

Similarly Scenario 3 is performed in columns L-N, taking cashflows from "Banana Projections 3".

Reasonableness checks:

- As expected, Scenario 2 results in a significant loss to the company. The lower volume of bananas collected increases the burden of the fixed costs, and the higher rates of deterioration ("transition") have a significant negative impact on the overall quality after transportation, and hence on the amount of income received from the retailers.
- Not surprisingly, Scenario 3 results in a small additional profit to the company. The Grade C bananas deteriorate quickly, with a high proportion becoming rotten during transportation over the full 50 days (at a rate of 2% per day). The cost of transporting these Grade C bananas exceeds the benefit obtained from the sales of the (low) proportion that has not gone rotten.
- The IRR results are consistent with the NPV results: the IRR under Scenario 1 is higher than the risk discount rate, as would be expected since the latter gives a positive NPV profit contribution. Under Scenario 2 the IRR falls significantly, and in Scenario 3 it has increased.

Charts

This worksheet brings in data from the Scenario 1 and 2 worksheets on the numbers of bananas at each Grade during the 20 days of shipping from Depot to Retailers.

These are then used to draw a line chart, one for each Scenario.

Reasonableness checks:

- Scenario 1: the number of Grade A bananas should reduce year on year, as this grade has only decrements and no increments. Grades B and C should also decline year on year: there are now increments (from higher Grades that have deteriorated) as well as decrements, but the rate of decrement is higher than the rate of increment. The Grade F (rotten) bananas should increase over time, as once a banana is rotten it stays rotten, and other rotten bananas join this Grade every day. [This pattern is shown in this graph]
- Scenario 2: the doubling of the transition rates should result in the decline in Grades A, B and C being faster (as these Grades all have a net outflow) and the increase in Grade F (rotten) bananas should also correspondingly be much faster. [This pattern is shown in this graph]

END

