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Cost-Benefit Analysis with Applications to Animal Health Programmes: Spreadsheet Implementation of Discounted Cash Flow and Risk Analysis

by

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This is number three of a set of six papers by Dr S. Harrison on 'Cost-Benefit Analysis with Applications to Animal Heath Programmes' to be published in this series Research Papers and Reports in Animal Health Economics.

Papers in this Set

1.   Cost-Benefit with applications to Animal Health Programmes: Basics of CBA, Research Paper or Report No. 18.

2.   Cost-Benefit Analysis with Applications to Animal Health Programmes: Complexities of CBA, Research Paper or Report No. 19.

3.   Cost-Benefit Analysis with Applications to Animal Health Programmes: Spreadsheet Implementation of Discounted Cash Flow and Risk Analysis, Research Paper or Report No. 20.

4.   Cost-Benefit Analysis with Applications to Animal Health Programmes: Allowing for Project Risk in CBA, Research Paper or Report No. 21.

5.   Cost-Benefit analysis with applications to Animal Health Programmes: Valuation of Non-Market Costs and Benefits, Research Paper or Report No.22.

6.   Cost-Benefit Analysis with Applications to Animal Health Programmes: Animal Health Programmes and Information Systems, Research Paper or Report No. 23.

Cost-Benefit Analysis with Applications to Animal Health Programmes: Spreadsheet Implementation of Discounted Cash Flow and Risk Analysis

ABSTRACT

Cost-benefit analysis on an animal health program involves considerable data collection and analysis. The analysis step involves expressing data in the form of cash flows, and then performing discounted cash flow (DCF) analysis. The output of DCF analysis consists of one of more of the various economic performance criteria - such as net present value, internal rate of return and benefit-to-cost ratios - which assist decision makers in judging whether to proceed with a project. This discussion paper examines the 'hands-on' side of cost-benefit analysis, viz. using a computer to carry out the analysis. Here, cash flow data are entered into electronic spreadsheet, and the various spreadsheet financial functions and presentation features are utilized to summarise estimated project performance.

Keywords: Cost-benefit analysis, animal health, discounted cash flow

JEL Classification: Q16, E37

Cost-Benefit Analysis with Applications to Animal Health Programmes: Spreadsheet Implementation of Discounted Cash Flow and Risk Analysis

1. INTRODUCTION

Cost-benefit analysis on an animal health program involves considerable data collection and analysis. The analysis step involves expressing data in the form of cash flows, and then performing *discounted cash flow* (DCF) analysis. The output of DCF analysis consists of one of more of the various economic performance criteria - such as net present value, internal rate of return and benefit-to-cost ratios - which assist decision makers in judging whether to proceed with a project.

This discussion paper examines the 'hands-on' side of cost-benefit analysis, viz. using a computer to carry out the analysis. Here, cash flow data are entered into electronic spreadsheet, and the various spreadsheet financial functions and presentation features are utilized to summarise estimated project performance.

This part of the analysis is interesting in that the hard work of compiling cash flows has been undertaken, and results of the task start to emerge in terms of the computed performance criteria. In addition, most people find working with computers to be of interest. It is less intellectually demanding in that the spreadsheet format is relatively standard, and financial functions are available for the difficult calculations, so that very little 'programming' effort is involved. From experience in lecturing on CBA to university students, a computing session results in a welcome change of pace and, more importantly, ties together a lot of seemingly abstract theory into a focused exercise on deriving and interpreting performance criteria. Working with some cash flow numbers and generating some NPV and IRR results somehow makes the whole topic more concrete.

It is to be stressed that this is not the critical part of any CBA, and that the results of computer analysis are only as good as the data on which they are based. That is, the well-known *gigo* principle (garbage in garbage out) must be kept in mind. These reservations aside, microcomputers and modern spreadsheet packages have made a wonderful difference to the application of discounted cash flow analysis techniques. Some of the important features are

ease of data entry, availability of a range of financial functions, convenience in exploring the impact on estimated project performance of changes in assumptions of the analysis, and graphics capability for presentation of results. As well, spreadsheets are sometimes linked to other software packages. For example, a risk analysis program may be run as an add-on to a spreadsheet, output from other program may be read into a spreadsheet, and spreadsheet tables and graphs may be incorporated into a word processor document.

Three of the widely used spreadsheet packages for the discounted cash flow (DCF) analysis part of CBA are Lotus 1-2-3 (from Lotus Corporation), Microsoft's Excel and Quattro Pro, developed by Borland Corporation. All tend to perform similar functions, and a person proficient in one can usually pick up another quite quickly. It is usually possible to copy spreadsheets developed under one package to another package.

In this paper, a simple example is provided of setting up a spreadsheet of discounted cash flow (DCF) analysis. Presentation format, data input, use of financial functions, drawing graphs and printing results will be examined. As well, sensitivity and risk analysis will be illustrated. The computer software packages for this example will be Excel (from Microsoft Office Professional), working in a Windows environment, and @RISK (a risk simulation add-on to Excel).

2. SETTING UP THE DCF SPREADSHEET

2.1 Basic skills and obtaining assistance

A number of basic survival skills are involved in using spreadsheets. These include calling up the spreadsheet package, loading and saving spreadsheets, data entry and corrections, adding extra rows and columns, selecting blocks of cells, moving data, creating formulae, printing and graphing. It will be assumed that the reader has basic skills with, or access to advice about, these procedures.

Even people experienced in using spreadsheets sometimes forge some of the steps, e.g. how to set up a formula to derive the net present value. Also, invariably the analyst will wish to carry out steps not attempted previously. There are three guiding principles to becoming expert on using spreadsheet packages (or any other computer packages for that matter), apart from calling for help from someone else; these are:

- experiment a lot (it won't hurt the computer)

- use the HELP facility in the spreadsheet package (that's what it is there for), and

- when still in doubt, read the manual.

2.2   Example project

For illustration purposes, an example of setting up a spreadsheet will be provided with reference to the data in the cash flow data in Table 1. The project has an immediate capital outlay of $25,000, with annual expenditures in each three years of $4000, and generates revenue in each of three years of $15,000. Project benefits are assumed to be received at the end of the year, while operating costs are divided equally between the start and end of year. Experience indicates that if a person can set up a simple spreadsheet such as the one illustrated here, they can readily extend computing skills to more realistic problems involving larger and perhaps multiple spreadsheets.

Table 1:   Annual cash flows for a hypothetical project

Year	Project benefits ($)	Capital outlays ($)	Operating costs ($)	Net cash flow ($)
0	0	25000	2000	-27000
1	15000	0	4000	11000
2	15000	0	4000	11000
3	15000	0	2000	13000

2.3   Setting up the spreadsheet title and parameter values

Once the spreadsheet package has been called up and a blank spreadsheet obtained, it is necessary to set up the headings for the DCF table. Suppose we wish to produce the spreadsheet presented as Table 2. This table is not the contents of the spreadsheet on the computer, but rather that results of the calculations directed by the formulate within the spreadsheet.

Note that spreadsheet is made up of a number of columns (represented by the letters A, B, C,...) and rows (represented by the numbers 1, 2, 3, ...). First position the cursor on the second cell of the first row (i.e. cell B1), and type in the spreadsheet title, i.e.

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It is of no concern that this heading spreads over five spreadsheet columns. Note that the text which is being typed appears both in cell B1 and in a window above the spreadsheet. After a 'text string' has been entered, it can be edited by highlighting the cell where it commences (here B1) and clicking on the text in this window.

Table 2:   Spreadsheet for hypothetical project

Annual discount rate =		8%		
Annual project revenue =		15000		
Initial capital outlay =		25000		
Annual project costs =		4000		

Year	Project benefits ($)	Capital outlays ($)	Operating costs ($)	Net cash flow ($)	Project balances ($)
0	25000	2000	-27000	-27000	-27000
1	15000		4000	11000	-16815
2	15000		4000	11000	-7384
3	15000		2000	13000	2936

NPV ($) =	2936
IRR (%)=	13.76%
PV of benefits ($) =	38656
PV of capital outlays ($) =	25000
PV of operating costs ($) =	10721
Gross 8/C ratio=	1.08
Net 8/C ratio =	1.12

The second row of the spreadsheet consists of two separate entries. First type the text

Annual discount rate =

in cell A3, then 8% in cell D3. Note that the interest or discount rate is in a cell on its own. This is necessary because we want to use this value for discounting, which would not be possible if it were part of a text string. Further, we want to be able to make changes to the discount rate to see what effect assumptions about the rate have on project profitability. It is a common practice to place parameters we may wish to vary in a convenient position (such as at the top of the spreadsheet) so that they are easy to access when making changes in

sensitivity analysis.

2.4   Setting up table headings

The headings and values for project revenues and costs are next entered. First type the column headings (Year ($), Project benefits ($), etc) in cells A8 through to E10. As well, a heading called 'Project balances ($)' will be included, in cells F8 to F10. Column widths can be adjusted if desired by "clicking and dragging" on the column borders at the top of the spreadsheet. The appearance of the spreadsheet will be improved if text is centred or right-justified, by selecting headings as a block then clicking on the appropriate orientation icon in the lower line of the menu bar. Although the spreadsheet already has gridlines to separate rows and columns, more prominent horizontal lines may be introduced by selecting the text rows and clicking on the lines icon, also in the lower line of the menu bar.

2.5   Entering the cash flow data into the spreadsheet

Having set up the headings and discount rate, the next step is to enter the cash flow data. Values are typed into the columns for the year and the three cash flow components. For the year, the four values can simply be typed in. Alternatively, a zero can be entered in cell A11, then

$$=a11+1$$

in cell A12, then the value from cell A12 copied to cells A13 and A14. For a longer project life - such as 20 years - this copying procedure is recommended since it saves time keying in years. Copying is performed by selecting the **Edit** menu then using either the **Copy** or **Fill** command. The latter is the simplest; select the block including the source and target cells then use the **Fill** and **Column** commands. It is to be noted that what is displayed in the spreadsheet is the numerical result of the calculations, not the formulae as entered. However, the formula in any cell can always be read by positioning the cursor on that cell. Note that formulae may be entered in lower or upper case (e.g. = A11+1 or = a11+1); generally, lower case is more convenient, but the formulae will be converted automatically to upper case.

When entering the project benefits and operating costs, these could simply be typed as numbers, but we will instead enter them as formulae, linking with the parameter values as the top of the spreadsheet. Under project benefits in Year 1 (cell B12), enter

$$=\$d\$4$$

then copy or fill this formula for cells B13 and B14. Note the inclusion of the dollar signs here. This ensures that when the contents of cell B12 are copied to cells below it, copying will be done in absolute and not relative terms. The default for copying is the relative form, where cell references are automatically adjusted; absolute copying anchors values at that in cell D3.

For cell C11, enter

$$=\$d\$5$$

For cell D11, enter

$$=\$d\$6/2$$

This formula can also be entered in cell D14, while cells D12 and D13 should contain

$$=\$d\$6$$

2.6   *Deriving the net cash flows and project balances*

The net cash flow column involves the first calculations in the spreadsheet. In cell E11, enter the formula

$$=b11-c11-d11$$

and copy this formula to cells E12 to E14. This will be a relative copy, in which the row numbers will adjust to each new row (e.g. the formula in cell E12 will appear as =B12-C12-D2). Next, the project balances or cumulative discounted net cash flows will be calculated. The first, entered in cell F11, is simply the net cash flow in Year 0, i.e.

$$=e11$$

The next is the sum of this figure and the discounted value of the net cash flow in Year 1, i.e.

$$=f11+e12/(1+\$d\$3)\wedge a12$$

This formula is then copied into cells F13 and F14. Inspection of this column indicates the NPV, payback period and peak deficit. Note that the slash is used as a divide sign and the caret '∧' is used to indicate raising to a power.

2.7   Deriving the DCF performance criteria

Having set up the annual net cash flows, the performance criteria can now be derived. First enter the row captions

$$\text{NPV (\$) =}$$

$$\text{IRR (\%) =}$$

and so on, from cell A15 to cell A21, and add a line across the bottom of the table (under A21 to F21). Then in cell E15, enter the NPV formula

$$\text{=npv(\$d\$3,e12:e14)+e11}$$

Here the financial function for net present value is called up for use. Note that arguments for the NPV function include first the discount rate and then the range of cells. Also, the net cash flow in Year 0, which is not to be discounted, is not included in the cell range within the parentheses. If the result of this formula is a series of hashes, this indicates the output field is not wide enough. The default format for NPV may include a dollar sign, a comma for thousands, and two or more decimal places. This problem can be overcome by using the Format and Cells command, and changing the output format to numbers with zero decimal places. (Alternative approaches are to click on the icon for reducing the number of decimal places or to make the column wider.)

The financial formula for deriving internal rate of return is next called up, in cell E16, as

$$\text{=irr(e11:e14)}$$

An alternative form for this function is to include an initial guess, written after the cash flow range, e.g. =irr(e11:e14,15%). To derive the benefit-cost ratios, it is convenient to first obtain present values for each of the three cash flow components, in cells E17 to E19, as

$$\text{=npv(\$d\$3,b12:b14)}$$

$$\text{=c11}$$

$$\text{=npv(\$d\$3,d12:d14)+d11}$$

The formulae for the gross and net B/C ratios, in cells E20 and E21, then become

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$$=e17/(e18+e19)$$

$$=(e17-e19)/e18$$

The benefit-to-cost ratios can now be obtained, by entering in cells D21 and D22 the formulae

$$+d19/(d20+d21)$$

$$+(d19-d21)/d20$$

It is desirable to fix the number of decimal places in cells D17 to D23. The IRR in cell D18 could be presented with four decimal places, while two decimal places is adequate for the other cells. As a final step, horizontal lines or boxes may be inserted to enhance the overall appearance of the spreadsheet.

2.8 Printing the spreadsheet

Once a spreadsheet has been set up, it is of course necessary to print the detail as displayed on the computer screen. The **Print** command is available under the **File** menu. If only part of a spreadsheet is to be printed, it is necessary to highlight a block of cells and indicate that only this selection is to be printed. It is a good idea to first see what the printed spreadsheet would look like before printing, and this can be done by choosing the **Print Preview** option. Changes may then be made to improve appearance, including

- if the orientation is landscape changing it to portrait

- removing the gridlines, using the **Tools** and **Options** commands

- removing the default header and footer

- widening the left margin to centre the output on the page (click and drag with the mouse button).

2.9 Saving and retrieving a spreadsheet

The spreadsheet should be saved (e.g. on a 3.5" disk) in case it is needed again. Saving is performed through the **File** and **Save As** command, and providing a file name. The file can later be accessed through the **File** and **Open** commands.

2.10 Graphing values in the spreadsheet

Often it is instructive to print graphs of project costs, benefits and net cash flows. These profiles of cash flow components can be particularly interesting to decision makers, depicting the rate at which (typically) capital costs decrease while benefits and net cash flows increase over time. Drawing graphs on a spreadsheet package is not difficult, but does require some practice and experimenting to obtain well-presented results. A range of types of graphs are available, but line graphs would be suitable for cash flow profiles.

Figure 1 provides an example of the type of graphs which may be produced. This graph indicates that the net cash flows become positive from Year 1, and that the project balances increase in approximately a linear fashion to become positive in Year 3. While the same information is available from the Table 2, often decision makers can relate more readily to graphs than large tables, i.e. graphical presentation aids communication of CBA results.

Figure 1:   Net cash flows and project balances
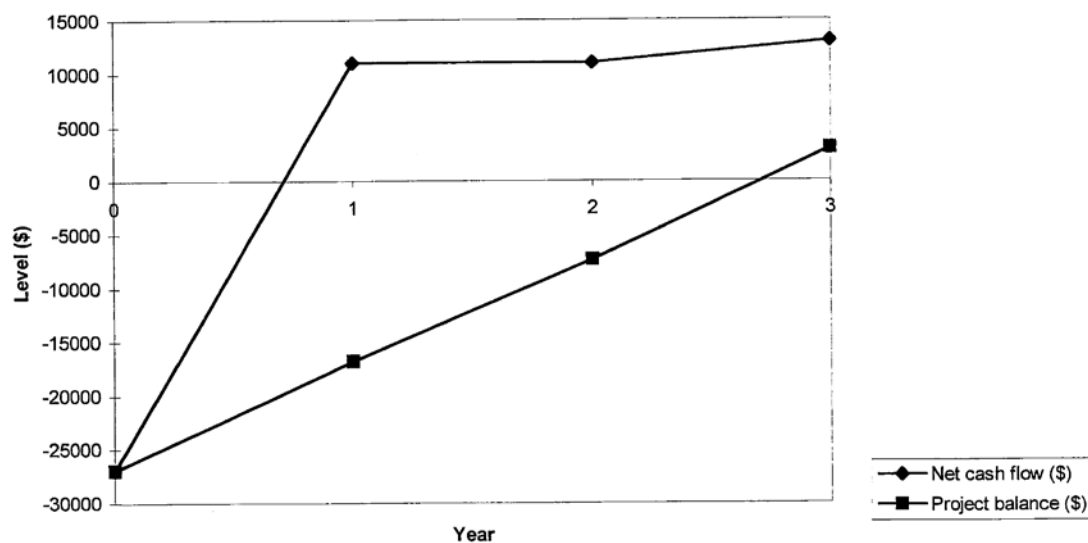
To produce a graph such as Figure 1, select the columns to be graphed in the spreadsheet, including not only the data values but the column titles as well. First, using the mouse pointer, select the year column. Then place the cursor at the top of the net cash flow column and, holding the Control key down, select the net cash flows and project balances as additional columns. Next click on the icon for the **Chart Wizard**, and proceed through a series of prompts. In response to these prompts, respond with

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- the line graph

- type 1 of line graphs

- the column 1 as the x-axis

- the chart title and labels for the x-axis and y-axis as in Figure 1

- the **Finish** option.

The graph will then appear, but will require some improvements in presentation. The chart is selected by double-clicking with the mouse. The overall size and shape can be adjusted by clicking on the midpoint of any border and dragging with the mouse. It is useful to display a preview (under the **File** and **Print Preview** options) before printing. Default headers and footers may need to be removed.

3. PERFORMING SENSITIVITY ANALYSIS

When carrying out a cost-benefit analysis, it is usually necessary to perform a sensitivity analysis in which the effect of varying the most uncertain cash flow variables on estimated project performance is examined. If the critical parameters are set up conveniently at the top of the spreadsheet, it is a simple matter to change their values, and to observe the effect on performance variables. For example, suppose we wish to determine how NPV will vary for a number of levels of annual project revenue ($12000, $15000, $18000, $21000) and annual operating costs ($3000, $4000, $5000 and $6000). Each combination of project revenue and operating costs could be entered, the NPV noted, and the results keyed into a sensitivity analysis table. This would be a relatively simple through rather tedious task.

An alternative and somewhat easier way of generating a sensitivity analysis table is to use the **Table** option in the spreadsheet package. For the example data, this would involve the following steps:

1. choose a convenient place on the spreadsheet (say cell HS) and set up the frame of a two-way table in the following form:

=e15	12000	15000	18000	21000
3000				
4000				
5000				
6000				

The first entry in this table is simply the cell reference for where NPV is derived. The entries across the top are the annual project revenues, while those down the left are the annual operating costs.

2. Select this block of cells is new selected, and choose the Data and Tables options. In response to prompts, the row input cell (cell D3) and the column input cell (cell D5) are indicated, either by clicking on these cells or by typing the references in the spaces provided. On clicking on the OK button, the entire sensitivity analysis table will appear as below.

=e15	12000	15000	18000	21000
3000	-2115	5616	13347	21078
4000	-4796	2936	10667	18398
5000	-7476	256	7987	15718
6000	-10156	-2425	5307	13038

3. Modify the format of the table to a form suitable for use in a report. This could involve adding a title and row and column headings, and hiding the cell reference E15. Instructions for how to *hide* any part of a spreadsheet can be obtained under the **Help** option.

4. PERFORMING RISK ANALYSIS

A useful addition to DCF analysis is to specify probability distributions of the most uncertain variables, and to generate or sample values at random from these distributions when deriving cash flows and hence performance criteria. The analysis can be repeated a large number of times, with the performance criteria derived for each new set of cash flows. In this way, the estimated probability distributions of say NPV and IRR can be obtained. The spreadsheet add-on @RISK allows this type of analysis to be performed.

To use risk analysis, it is necessary to log in to the computer from the @RISK icon, and not

directly from Excel. A blank spreadsheet will appear on the screen, but with a second menu bar under the normal Excel menu. At this stage, it is possible to load an existing Excel spreadsheet. With @RISK, the contents of any cell can be a probability distribution rather than a single value or formula. More than 30 forms of probability distributions are available. Two of the best know and the normal and triangular distributions. A triangular distribution is specified in terms of the pessimistic or lowest value which it is though the variable could take, the most likely value, and the extreme upper or optimistic value. Suppose the annual project revenues and costs of Table 2 cannot be predicted exactly, but can be specified as triangular probability distributions as in Table 4.

Table 4:   Triangular probability distributions of project revenue and costs

Cash flow variable	Pessimistic value	Best guess	Optimistic value
Annual project revenue	12000	15000	20000
Annual project cost	3000	4000	5500

These distributions can be entered into the spreadsheet by typing

=RiskTriang(12000,15000,20000) in cell D3, and

=RiskTriang(3000,4000,5500) in cell D5.

Every time the values in the spreadsheet are recalculated, new values will be selected from each of these probability distributions.

To apply risk analysis, it is necessary to recalculate the cash flows and performance criteria a large number of times, and to derive relative frequency distributions (approximate probability distributions) of the performance criteria. The distribution of NPV, for example, can then be expressed as a cumulative relative frequency curve, and the estimated probability of making a loss or obtaining NPVs over various ranges can then be read from this curve.

The @RISK program has two menu forms. When the spreadsheet is visible, a number of icons are present under the Excel menu. The critical ones of these are the third to sixth icon, viz.

- Change @RISK settings

- Add selected cells as @RISK output

- Display inputs by outputs table

- Run simulation.

When the simulation output rather than the spreadsheet is visible, the Excel menu disappears and a larger menu of the following form is present:

Open a file	Save a file	Simulation settings	Output	List	Simulate	Results	Graph	Summary	Hide

The **Output** option is used to select the performance variables for which probability distributions are to be derived. Suppose this is the NPV alone. The cell in which NPV is calculated (E15) is first highlighted, then the **Output** option is selected. Selecting the **List** option produces a table of inputs and outputs in place of the spreadsheet; it is possible to return to the spreadsheet by choosing the **Hide** option.

The **Simulation settings** option is used to specify how many iterations of the analysis are to be are to be performed; i.e. how many values of NPV are to be generated. The default number of 100 is usually too small, leading to an erratically shaped cumulative distribution; 500 may be a more appropriate number. Selecting the **Simulate** option causes the simulation analysis to be performed. Once output values have been generated, the **Graph** option is a useful way of displaying the results. The default form of graph is a bar chart, but clicking anywhere on the graph with the right mouse button will call up a menu from which the form may be changed to a more useful form of relative frequency distribution (cumulative ascending, outline, fitted curve). The concepts underlying risk analysis and uses of this technique will be examined in more detail in a subsequent discussion paper.

5. CONCLUDING COMMENTS

This discussion paper has explained how to set up a spreadsheet to perform discounted cash flow analysis, given that project benefits, capital outlays and operating costs have been estimated.

Experience suggests that it is preferable when possible to include as much as possible of the

calculations underlying estimates of cash flows (e.g. project revenue and cost budgets) within the spreadsheet. This is particularly important when revisions have to be made to budgets, since the spreadsheet is then automatically revised. It also greatly assists when a sensitivity analysis has to be conducted in which a range of parameter values are included. As indicated above, any parameters which may need to be adjusted between spreadsheet runs - such as the discount rate, uncertain product prices and input costs - are best grouped together in a convenient location for ease of manipulation.

Having derived the performance criteria, it is usually desirable to perform sensitivity analysis with respect to the discount rate and most uncertain cash flow variables. Some form of breakeven analysis is also useful.

For anyone producing reasonably complex spreadsheets, it is desirable to study the manual. As well, many books are written about computer packages which are usually much more user-friendly than the manuals produced by software developers, and serious users should seek out the best of the titles.

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