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User's Guide to BENCOS--A SuperCalc Template For Benefit-Cost Analysis

by

Eric W. Crawford, Ting-Ing Ho
and A. Allan Schmid

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PREFACE

There is a worldwide revolution in small computer technology underway and scientists are struggling to find ways to utilize this new technology to help solve development problems in the Third World. We are pleased to announce a number of papers on microcomputers in international agriculture will be published in our International Development Paper series. The aim of these papers is to provide timely information about the rapidly changing state of the new micro-processing technology and its use in research. The papers are also intended as guides to agricultural and social scientists on choosing, installing, and maintaining microcomputer hardware and software systems in developing countries.

Some of the papers will also document field experiences of selected established projects using new data processing hardware and software. Other papers will concentrate on developing guidelines for establishing and maintaining successful microcomputer and/or programmable calculator installations for agricultural research in developing countries.

The present paper is the eighth of these new papers. It is based on work by faculty and staff of the Department of Agricultural Economics, Michigan State University, on cost-effective data collection, management, and analysis techniques for developing country applications. This activity is carried out under the terms of reference of the Alternative Rural Development Strategies Cooperative Agreement--DAN-1190-A-00-2069-00--between the Office of Multi-Sectoral Development, Bureau of Science and Technology of the United States Agency for International Development and the Department of Agricultural Economics at Michigan State University.

USER'S GUIDE TO BENCOS--A SUPERCALC
TEMPLATE FOR BENEFIT-COST ANALYSIS

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User's Guide to BENCOS--A SuperCalc Template for Benefit-Cost Analysis

By Eric W. Crawford and Ting-Ing Ho

1. Introduction

BENCOS is a SuperCalc template designed for benefit-cost analysis. It is adapted from BENCOST, a FORTRAN program written for the CDC Cyber 750 by Robert F. Ranger, Robert D. Stevens, Roy A. Saper, and Ting-Ing Ho. The current form of BENCOS is designed for relatively small problems. BENCOS was written on an IBM PC microcomputer, but its only requirements are 128K of RAM and SuperCalc. A diskette containing the BENCOS template, formatted for the IBM PC, can be obtained from MSU for $15.00.

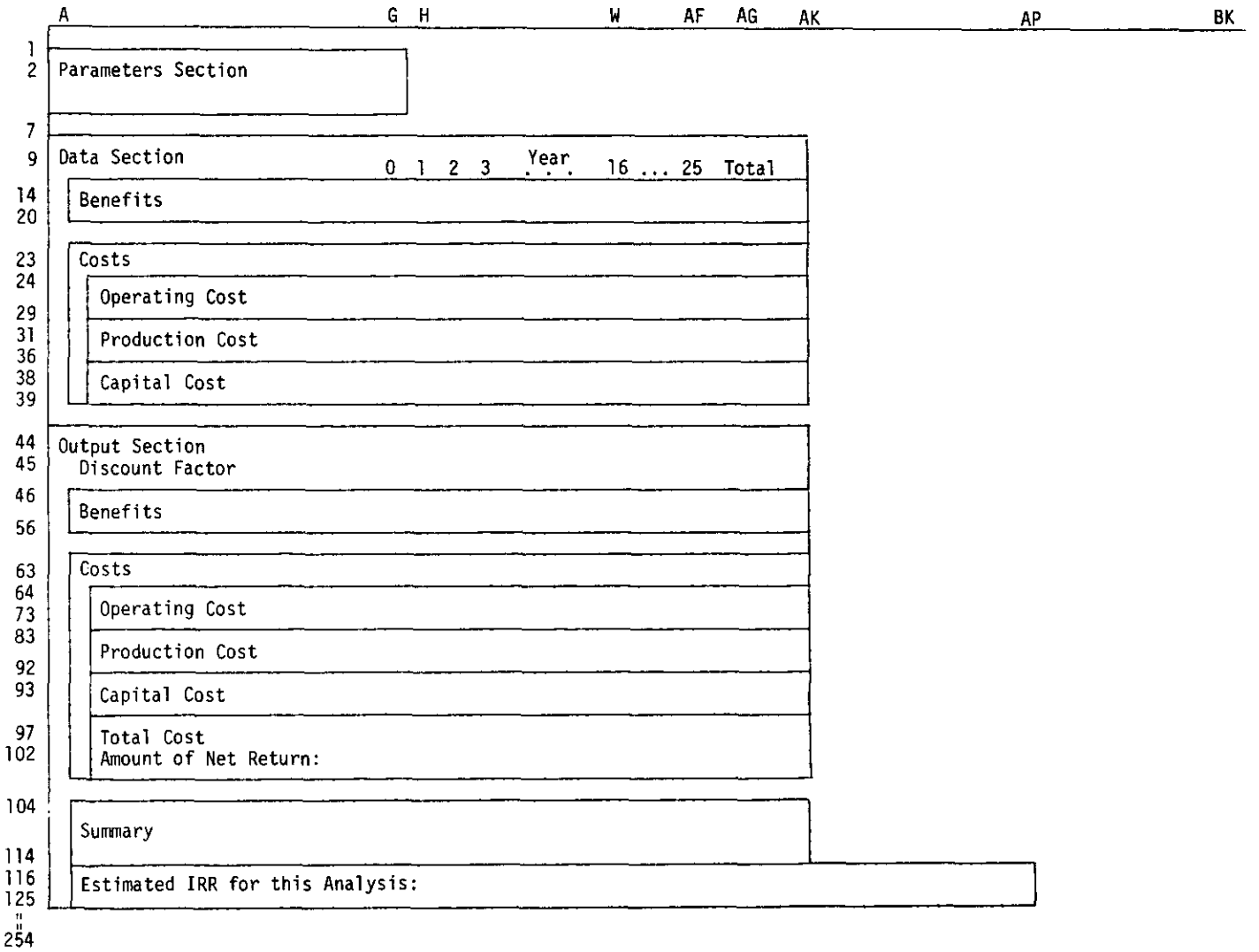
This guide assumes that the user is familiar with standard benefit-cost analysis techniques. A useful reference is J. Price Gittinger, Economic Analysis of Agricultural Projects, Second Edition, Baltimore, Johns Hopkins University Press, 1982. The concepts, structure, and calculations of BENCOS are generally consistent with those recommended by Gittinger.

This document begins with a description of the structure and capabilities of BENCOS, followed by instructions on how to use the template, and comments on possible modifications of the template.

2. Description of BENCOS

The BENCOS template is divided into four main sections: (1) Parameters Section, (2) Data Section, (3) Output Section, and (4) Summary. The abbreviated diagram of the spreadsheet in Figure 1 shows the row and column coordinates of these sections. A photocopy of the main sections of the spreadsheet is shown in Annex 1.

Figure 1. Diagram of BENCOS Spreadsheet



Annex 2 contains selected formulas. An expanded version of BENCOS which allows for calculation of terminal values is described in Annex 3.

2.1 Parameters Section

Three parameters must be entered in this section: number of years of the planning horizon, the interest rate, and the user's definition of capital or scarce resource costs. BENCOS currently allows up to 25 years of benefits and costs.

2.2 Data Section

Information on benefits and costs is entered here. Note that it is incremental benefits and costs which should be used, i.e., the difference between with-project and without-project figures. BENCOS currently allows for two categories each for benefits, operating costs, production costs, and capital costs. Operating costs are general project-level overhead costs (e.g., administration, maintenance of central facilities, etc.); production costs are the costs of producing project output (e.g., fertilizer, seed, hired labor, or other farm inputs). Data for each category can be entered either as values, or as separate sets of units and prices. The exception is that capital costs must be entered as values.

The BENCOS format allows a choice between the two standard ways of phasing initial costs and returns. One alternative is to enter initial investment (capital costs) in Year 0, with initial operating and production costs and initial benefits (if any) beginning in Year 1. Values in Year 0 are not discounted. The second alternative is to ignore Year 0 and to begin entering all initial costs and benefits (if any) in Year 1. Values in Year 1 are discounted by one year.

Prices may be entered directly for each year, or they may be projected automatically on the basis of a Year 0 or Year 1 price and an annual price compounding factor (defined by the user). A constant scale factor can also be defined for use in sensitivity analysis.

2.3 Output Section

This section first shows the discount factor for each year, based on the user-specified interest rate. Subsequent rows show the benefits and costs entered earlier by the user, the effect of the scale factor (if any), and the final values obtained as the product of price times quantity. The present value of the benefit and cost streams is also shown.

Total cost is the sum of operating, production, and capital costs. Excess of cost over return (C - B), amount of net investment, and amount of net return (rows 99-102) are presented in order to calculate the second alternative definition of scarce resource costs (see section 2.4 below, and Gittinger, op. cit., p. 347.)

2.4 Summary

The summary section contains the present value of total benefits and costs. Cash flow (undiscounted annual net benefits) and the present value of annual net benefits are shown. Three discounted benefit/cost ratios are calculated: (1) gross benefit/cost ratio (Benefits divided by Total Costs); (2) (Benefits minus Production Costs) divided by (Operating plus Capital Costs); and (3) the net benefit/scarce resource cost ratio. The third ratio is defined as either (a) (Benefits minus Operating and Production Costs) divided by the user-entered Capital or Scarce Resource Costs, or (b) the sum of values in years where

benefits exceed total costs, divided by the sum of values in years where total costs exceed benefits. The cost-effectiveness ratio is simply the reciprocal of the gross B/C ratio.

Lastly, the internal rate of return is calculated, along with the net present value and gross B/C ratio at successive 2 percent intervals (up to 80 percent) until NPV turns negative. Note: a two-row working space is created for the IRR calculation. "Lower npv" means NPV at the lower of the two interest rates used in the IRR calculation.

3. How to Use BENCOS

3.1 Loading the Template

First, load SuperCalc into memory once the A> prompt is obtained. It is generally sufficient to enter SC. When the SuperCalc trademark information appears, hit Return to obtain the spreadsheet. Then, load BENCOS into the spreadsheet as follows: type /L and SuperCalc will ask for the name of the file to load; then type BENCOS, A (or BENCOS (enter) A). Note: The initial calculation will take approximately one and a half minutes, during which the "Calculating . . ." message appears at the bottom. The titles and instructions will be at half-intensity on the screen because they are protected. Data you enter will be at full intensity.

3.2 Entering Parameters and Data

Note: Dashes are used to indicate each cell in which data may be entered. These dashes will be replaced by the numbers you enter.

Step 1: Enter the number of years of the planning horizon in cell E3.

Step 2: Enter the interest rate for discounting (in decimal form, e.g., enter 15% as .15) in cell E4.

Step 3: Enter either 1 or 2 in cell G5 to indicate your desired definition of capital or scarce resource costs. (See section 2.4.)

Step 4: Enter your benefit and cost data.

There are three sets of data which are entered in the same way: benefits, operating costs, and production costs.

Note: (a) With a column width of 9, and using the $ format, the output section allows room for only 5 digits to the left of the decimal point, so you should define your data as necessary (e.g., thousands or millions).

(b) Be careful to enter your data in the correct row and column. Otherwise, the program will not recognize what you have entered. Inspecting a print-out of your input data is a good way to check this.

(1) Constant scale factor: You may leave this blank initially. A figure may be entered later when you want to do sensitivity analysis. Entering 1.10 will cause the corresponding type of benefit or cost to be increased by a constant 10 percent for all years. A scale factor of 0.95 would reduce your numbers by 5 percent for all years. A scale factor of 1.0 will result in no change.

(2) Price compounding factor (PCF):

a) If you are entering your benefits or costs as values, enter 1.0 for the price compounding factor

and 1.0 as the price in Year 1 (or Year 0 if benefits or costs begin then).

b) If you are entering benefits or costs as units, in which case you need to enter a price per unit, you have two options:

   i) enter your own price value for each year leaving the PCF blank; or

   ii) enter an initial price in Year 0 or Year 1 and a price compounding factor. Prices for subsequent years will then be projected using this compounding factor. (Specifically, price in Year 1 will equal price in Year 0, if any; price in Year 2 will equal price in Year 1 times the PCF; price in Year 3 will equal price in Year 2 times $(PCF)^2$, and so on.)

c) Sensitivity analysis involving compounded increases or decreases may be performed later by changing the PCF.

(3) <u>Units and Prices of Benefits and Costs, excluding Capital Costs</u>: Two options are available:

a) To enter benefits or costs as values, enter your numbers in the units row and then enter a price of 1 in the initial year (see Step 4 (2) (a)).

b) Alternatively, enter the units in the units row followed by prices in the price row (see Step 4 (2) (b)).

(4) Capital costs: These must be entered as values.

(5) Note: The benefit/cost ratio calculations distinguish between operating and production costs. Organize your data entry with the definitions of the benefit/cost ratios in mind (see section 2.4).

Step 5: Once the Data Section is complete, save your worksheet (see Step 7). Then initiate recalculation. When this is complete, you can move around the worksheet to examine the results, or print them out as indicated below. Row totals are shown in column AG.

Note: If your results do not look right, you may have made an error in entering your data. The best way to check for errors is to print out the data input section, as shown below.

Step 6: Printing out convenient blocks of the worksheet can be done with the following commands:

(1) To obtain a copy of the complete worksheet using normal size type, enter the following commands in order:

/O, D, A1:H126, P (Type /O then D then A1:H126,
/O, D, I1:P126, P (or enter) and P)
/O, D, Q1:X126, P
/O, D, Y1:AF126, P
/O, D, AG1:AN126, P

You can then tape these five sections together.

Note: Printing the entire worksheet will take about ten minutes. If you find a cell filled with >>>>>> symbols, that means the number was too large.

Note: To obtain output with compressed type and 8 lines per inch on the IBM PC printer, use the SETUP option on the /O command. Change the number of lines per page by hitting L and then entering 88. Then hit S and enter ALT 15, ALT 27, and ALT 48 (they will not show on the screen). Then hit P to print. The spreadsheet can then be printed in 3 sections: A to M, N to Z, and AA to AM.

(2) To obtain a copy of the Summary section only, enter:

/O, D, A104:H126, P

/O, D, I104:P126, P

/O, D, Q104:X126, P

/O, D, Y104:AF126, P

/O, D, AG104:AN126, P

(3) To obtain a copy of the Data Section, e.g., for checking your data entry, use these commands:

/O, D, A9:H40, P

/O, D, I9:P40, P

/O, D, Q9:X40, P

/O, D, Y9:AF40, P

/O, D, AG9:AN40, P

Step 7: Saving your worksheet. If you wish to save your worksheet at any point, enter the following command:

/S, BCname, A

("BCname" is just a sample file name; it can be something else. Using "BENCOS" would cause you to overwrite the blank worksheet stored by that name, which you do not want to do. Write down the file name you use here.)

Step 8: Recalling a previously saved worksheet (after loading SuperCalc) can then be done by typing, for example: /L, BCname, A

4. Modifying the Template

There are several relatively straightforward modifications which the user may wish to make. Sections being modified would need to be unprotected first, and then reprotected using the /U and /P commands, respectively.

4.1 Blanking Row 119

The calculation of gross B/C ratios at successive two percent intervals is relatively time-consuming and may provide information of little interest to some users. Blanking out Row 119 (using the /B command) would reduce the memory requirements of the spreadsheet and reduce the calculation time from about 90 seconds to about 55 seconds, without affecting other values.

4.2 Vertical Titles

Users who find it difficult to keep track of what row they are in when entering data may wish to fix the titles in column A. However, this would show only the first nine characters of the present titles, which would not be self-explanatory. This can be remedied either by rewriting the titles in condensed form, or (more simply) by inserting a new column of one-word acronyms in front of column A. Fixing the vertical titles would then keep this information on screen. Of course, the condensed titles would not have to be shown on any printed output.

4.3 More Years or Cost/Benefit Items

By inserting new rows, additional categories of benefits or costs could be accommodated. Some adjustment of formulas in the output section would be required. It is also possible to insert columns for additional years, or to expand the width of existing columns G to AF, providing care is taken not to disrupt the layout of the bottom part of the Summary section.

Annex 1: Main Section of the Spreadsheet

```
 |  A  ||  B  ||  C  ||  D  ||  E  ||  F  ||  G  ||  H  ||  I  ||  J  ||  K  ||  L  ||  M  |
 1|** BENCOS ** By Ting-Ing Ho & Eric W. Crawford (Michigan State Univ.)
 2|PARAMETERS SECTION
 3| Planning Horizon =                >>     -   <<  years
 4| Interest Rate for Discounting =  >>     -   <<  (enter a decimal value)
 5| Definition of Capital or Scarce Resource Costs =   >>     -   <<
 6|   (1: as entered in rows 38 & 39)
 7|   (2: excess of cost over return, row 99)
 8|*****************************************************************************************************************
 9|DATA SECTION
10|*NOTE*  You have two options for entering prices:
11|        (A) Enter price manually for each year;
12|        (B) Enter initial price and price compounding factor.
13|                                                   Year 0   Year 1   Year 2   Year 3   Year 4   Year 5   Year 6
14| Benefits
15|  Benefit 1:
16|  (constant scale factor =       -  )        units      -        -        -        -        -        -        -
17|  (price compounding factor      -  )        price      -        -        -        -        -        -        -
18|  Benefit 2:
19|  (constant scale factor =       -  )        units      -        -        -        -        -        -        -
20|  (price compounding factor      -  )        price      -        -        -        -        -        -        -
21|
22|                                                   Year 0   Year 1   Year 2   Year 3   Year 4   Year 5   Year 6
23| Costs
24|  Operating Cost 1:
25|  (constant scale factor =       -  )        units      -        -        -        -        -        -        -
26|  (price compounding factor      -  )        price      -        -        -        -        -        -        -
27|  Operating Cost 2:
28|  (constant scale factor =       -  )        units      -        -        -        -        -        -        -
29|  (price compounding factor      -  )        price      -        -        -        -        -        -        -
30|
31|  Production Cost 1:
32|  (constant scale factor =       -  )        units      -        -        -        -        -        -        -
33|  (price compounding factor      -  )        price      -        -        -        -        -        -        -
34|  Production Cost 2
35|  (constant scale factor =       -  )        units      -        -        -        -        -        -        -
36|  (price compounding factor      -  )        price      -        -        -        -        -        -        -
37|
38|  Capital Cost(or Scarce Resource) 1:                  -        -        -        -        -        -        -
39|  Capital Cost(or Scarce Resource) 2:                  -        -        -        -        -        -        -
40|
41|*****************************************************************************************************************
42|
43|                                                   Year 0   Year 1   Year 2   Year 3   Year 4   Year 5   Year 6
44|OUTPUT SECTION
45| Discount Factor        (at        0 %)              1        1        1        1        1        1        1
46| Benefits
47|  Benefit 1: (units)                              .00      .00      .00      .00      .00      .00      .00
48|             (price)                              .00        0      .00      .00      .00      .00      .00
49|             (price*scale)                        .00      .00      .00      .00      .00      .00      .00
50|             (revenue)                            .00      .00      .00      .00      .00      .00      .00
51|  Benefit 2: (units)                              .00      .00      .00      .00      .00      .00      .00
52|             (price)                                0        0      .00      .00      .00      .00      .00
53|             (price*scale)                        .00      .00      .00      .00      .00      .00      .00
54|             (revenue)                            .00      .00      .00      .00      .00      .00      .00
55|  Total Benefits                                  .00      .00      .00      .00      .00      .00      .00
56|  Present Value of Benefits                       .00      .00      .00      .00      .00      .00      .00
57|
58|
59|
60|*****************************************************************************************************************
61|
62|                                                   Year 0   Year 1   Year 2   Year 3   Year 4   Year 5   Year 6
63| Costs
64|  Operating Cost 1:  (units)                       .00      .00      .00      .00      .00      .00      .00
65|                     (price)                       .00        0      .00      .00      .00      .00      .00
66|                     (price*scale)                 .00      .00      .00      .00      .00      .00      .00
67|                     (cost)                        .00      .00      .00      .00      .00      .00      .00
68|  Operating Cost 2:  (units)                       .00      .00      .00      .00      .00      .00      .00
69|                     (price)                       .00      .00      .00      .00      .00      .00      .00
70|                     (price*scale)                 .00      .00      .00      .00      .00      .00      .00
71|                     (cost)                        .00      .00      .00      .00      .00      .00      .00
72|  Total Operating Cost                            .00      .00      .00      .00      .00      .00      .00
73|  Present Value of Operating Cost                  .00      .00      .00      .00      .00      .00      .00
74|
75|
76|
77|
78|
```

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Production Cost 1: (units)	.00	.00	.00	.00	.00	.00	.00
(price)	.00	.00	.00	.00	.00	.00	.00
(price*scale)	.00	.00	.00	.00	.00	.00	.00
(cost)	.00	.00	.00	.00	.00	.00	.00
Production Cost 2: (units)	.00	.00	.00	.00	.00	.00	.00
(price)	.00	.00	.00	.00	.00	.00	.00
(price*scale)	.00	.00	.00	.00	.00	.00	.00
(cost)	.00	.00	.00	.00	.00	.00	.00
Total Production Cost	.00	.00	.00	.00	.00	.00	.00
Present Value of Production Cost	.00	.00	.00	.00	.00	.00	.00
Capital Cost 1	.00	.00	.00	.00	.00	.00	.00
Capital Cost 2	.00	.00	.00	.00	.00	.00	.00
Total Capital Cost	.00	.00	.00	.00	.00	.00	.00
Present Value of Capital Cost	.00	.00	.00	.00	.00	.00	.00
Total Cost	.00	.00	.00	.00	.00	.00	.00
Present Value of Total Costs	.00	.00	.00	.00	.00	.00	.00
Excess of Cost over Return	.00	.00	.00	.00	.00	.00	.00
Present Value of Excess of Cost Over Return	.00	.00	.00	.00	.00	.00	.00
Amount of Net Investment: (C-B)>0	.00	.00	.00	.00	.00	.00	.00
Amount of Net Return: (C-B)<0	.00	.00	.00	.00	.00	.00	.00

Summary	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cash Flow (Undiscounted Net Benefit)	.00	.00	.00	.00	.00	.00	.00
Present Value of Benefits (at 0%)	.00	.00	.00	.00	.00	.00	.00
Present Value of Total Costs (at 0%)	.00	.00	.00	.00	.00	.00	.00
Present Value of Net Benefit (at 0%)	.00	.00	.00	.00	.00	.00	.00

Gross B/C Ratio = ERROR
Net Benefit/Scarce Resource Cost Ratio = ERROR
Ratio of (Benefit - Prod Costs)/(Operating Costs + Capital Costs) = ERROR
Cost-Effectiveness Ratio = ERROR

Estimated Internal Rate of Return (IRR) for this Analysis:

Interest Rate	.02	.04	.06	.08	.10	.12	.14	.16	.18	.20	.22
Net Present Value	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Gross B/C Ratio	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR

(Working Space, i	.02	.04	.06	.08	.1	.12	.14	.16	.18	.2	.22

(Working Space, lower i = .78,lowernpv 0; hi npv 0)

The Internal Rate of Return (IRR) =ERROR or ERROR PERCENT
(If reported IRR > 78%, check row 119. If NPV at 80% > 0, IRR > 80%.)

AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP

~~~
~~~

Year 23	Year 24	Year 25	TOTAL	
.00	.00	.00	.00	(Units, Prod Cost 1)
.00	.00	.00		
.00	.00	.00		
.00	.00	.00	.00	(Value, Prod Cost 1)
.00	.00	.00	.00	(Units, Prod Cost 2)
.00	.00	.00		
.00	.00	.00		
.00	.00	.00	.00	(Value, Prod Cost 2)
.00	.00	.00	.00	(Total Prod Cost)
.00	.00	.00	.00	(PV of Prod Cost)
.00	.00	.00	.00	(Capital Cost 1)
.00	.00	.00	.00	(Capital Cost 2)
.00	.00	.00	.00	(Total Capital Cost)
.00	.00	.00	.00	(PV of Capital Cost)
.00	.00	.00	.00	(Total Cost)
.00	.00	.00	.00	(PV of Total Cost)
.00	.00	.00	.00	(Excess of Cost over Return)
.00	.00	.00	.00	(PV of Excess of Cost over Return)
.00	.00	.00	.00	(Amount of Net Investment)
.00	.00	.00	.00	(Amount of Net Return)

Year 23	Year 24	Year 25	TOTAL	
.00	.00	.00	.00	(Cash Flow)
.00	.00	.00	.00	(PV of Benefits)
.00	.00	.00	.00	(PV of Total Costs)
.00	.00	.00	.00	(Net Present Value)

.56	.58	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR

.56	.58	.6	.62	.64	.66	.68	.7	.72	.74	.76	.78	.8

Annex 2: Formulas Used in the Spreadsheet

```
SuperCalc ver.  1.10
** BENCOS ** By Ting-Ing Ho & Eric W. Crawford (Michigan State Univ.)
G45 G     P= 1
H45 G     P= 1/(1+E4)
I45 G     P= H45/(1+E4)
J45 G     P= I45/(1+E4)
G46 $     P=
H46 $     P=
I46 $     P=
J46 $     P=
G47 $     P= IF(G16>=0,G16,0)
H47 $     P= IF(H16>=0,H16,0)
I47 $     P= IF(I16>=0,I16,0)
J47 $     P= IF(J16>=0,J16,0)
G48 $     P= G17
H48 $     P= IF(AND(D17<>0,G17<>0),G17,H17)
I48 $     P= IF(D17<>0,H48*D17,I17)
J48 $     P= IF(D17<>0,I48*D17,J17)
G49 $     P= IF(D16>0,G48*D16,G48)
H49 $     P= IF(D16>0,H48*D16,H48)
I49 $     P= IF(D16>0,I48*D16,I48)
J49 $     P= IF(D16>0,J48*D16,J48)
G50 $     P= G49*G47
H50 $     P= H49*H47
I50 $     P= I49*I47
J50 $     P= J49*J47
G51 $     P= IF(G19>=0,G19,0)
H51 $     P= IF(H19>=0,H19,0)
I51 $     P= IF(I19>=0,I19,0)
J51 $     P= IF(J19>=0,J19,0)
G52 $     P= G20
H52 $     P= IF(AND(D20<>0,G20<>0),G20,H20)
I52 $     P= IF(D20<>0,H52*D20,I20)
J52 $     P= IF(D20<>0,I52*D20,J20)
G53 $     P= IF(D19>0,G52*D19,G52)
H53 $     P= IF(D19>0,H52*D19,H52)
I53 $     P= IF(D19>0,I52*D19,I52)
J53 $     P= IF(D19>0,J52*D19,J52)
G54 $     P= G53*G51
H54 $     P= H53*H51
I54 $     P= I53*I51
J54 $     P= J53*J51
G55 $     P= G50+G54
H55 $     P= H50+H54
I55 $     P= I50+I54
J55 $     P= J50+J54
G56 $     P= G55*G45
H56 $     P= H55*H45
I56 $     P= I55*I45
J56 $     P= J55*J45
G62       P= "Year 0
H62       P= "Year 1
I62       P= "Year 2
J62       P= "Year 3
G64 $     P= IF(G25>=0,G25,0)
H64 $     P= IF(H25>=0,H25,0)
I64 $     P= IF(I25>=0,I25,0)
J64 $     P= IF(J25>=0,J25,0)
G65 $     P= G26
H65 $     P= IF(AND(D26<>0,G26<>0),G26,H26)
I65 $     P= IF(D26<>0,H65*D26,I26)
J65 $     P= IF(D26<>0,I65*D26,J26)
G66 $     P= IF(D25>0,G65*D25,G65)
H66 $     P= IF(D25>0,H65*D25,H65)
I66 $     P= IF(D25>0,I65*D25,I65)
J66 $     P= IF(D25>0,J65*D25,J65)
G67 $     P= G66*G64
H67 $     P= H66*H64
I67 $     P= I66*I64
J67 $     P= J66*J64
G68 $     P= IF(G28>=0,G28,0)
H68 $     P= IF(H28>=0,H28,0)
I68 $     P= IF(I28>=0,I28,0)
J68 $     P= IF(J28>=0,J28,0)
G69 $     P= G29
H69 $     P= IF(AND(D29<>0,G29<>0),G29,H29)
I69 $     P= IF(D29<>0,H69*D29,I29)
J69 $     P= IF(D29<>0,I69*D29,J29)
G70 $     P= IF(D28>0,G69*D28,G69)
H70 $     P= IF(D28>0,H69*D28,H69)
I70 $     P= IF(D28>0,I69*D28,I69)
J70 $     P= IF(D28>0,J69*D26,J69)
G71 $     P= G70*G68
H71 $     P= H70*H68
I71 $     P= I70*I68
J71 $     P= J70*J68
G72 $     P= G67+G71
H72 $     P= H67+H71
I72 $     P= I67+I71
J72 $     P= J67+J71
G73 $     P= G72*G45
H73 $     P= H72*H45
I73 $     P= I72*I45
J73 $     P= J72*J45
G82       P= "Year 0
H82       P= "Year 1
I82       P= "Year 2
J82       P= "Year 3
G83 $     P= IF(G32>=0,G32,0)
H83 $     P= IF(H32>=0,H32,0)
I83 $     P= IF(I32>=0,I32,0)
J83 $     P= IF(J32>=0,J32,0)
G84 $     P= G33
H84 $     P= IF(AND(D33<>0,G33<>0),G33,H33)
I84 $     P= IF(D33<>0,H84*D33,I33)
J84 $     P= IF(D33<>0,I84*D33,J33)
G85 $     P= IF(D32>0,G84*D32,G84)
H85 $     P= IF(D32>0,H84*D32,H84)
I85 $     P= IF(D32>0,I84*D32,I84)
J85 $     P= IF(D32>0,J84*D32,J84)
G86 $     P= G85*G83
H86 $     P= H85*H83
I86 $     P= I85*I83
J86 $     P= J85*J83
G87 $     P= IF(G35>=0,G35,0)
H87 $     P= IF(H35>=0,H35,0)
I87 $     P= IF(I35>=0,I35,0)
J87 $     P= IF(J35>=0,J35,0)
G88 $     P= G36
H88 $     P= IF(AND(D36<>0,G36<>0),G36,H36)
I88 $     P= IF(D36<>0,H88*D36,I36)
J88 $     P= IF(D36<>0,I88*D36,J36)
G89 $     P= IF(D35>0,G88*D35,G88)
H89 $     P= IF(D35>0,H88*D35,H88)
I89 $     P= IF(D35>0,I88*D35,I88)
J89 $     P= IF(D35>0,J88*D35,J88)
G90 $     P= G89*G87
H90 $     P= H89*H87
I90 $     P= I89*I87
J90 $     P= J89*J87
G91 $     P= G86+G90
H91 $     P= H86+H90
I91 $     P= I86+I90
J91 $     P= J86+J90
G92 $     P= G91*G45
H92 $     P= H91*H45
I92 $     P= I91*I45
J92 $     P= J91*J45
G93 $     P= IF(G38>=0,G38,0)
H93 $     P= IF(H38>=0,H38,0)
I93 $     P= IF(I38>=0,I38,0)
J93 $     P= IF(J38>=0,J38,0)
G94 $     P= IF(G39>=0,G39,0)
H94 $     P= IF(H39>=0,H39,0)
I94 $     P= IF(I39>=0,I39,0)
J94 $     P= IF(J39>=0,J39,0)
G95 $     P= G93+G94
H95 $     P= H93+H94
I95 $     P= I93+I94
J95 $     P= J93+J94
G96 $     P= G95*G45
H96 $     P= H95*H45
I96 $     P= I95*I45
J96 $     P= J95*J45
G97 $     P= G72+G91+G95
H97 $     P= H72+H91+H95
I97 $     P= I72+I91+I95
J97 $     P= J72+J91+J95
G98 $     P= G97*G45
H98 $     P= H97*H45
```

```
I98 $     P= I97*I45
J98 $     P= J97*J45
G99 $     P= G97-G55
H99 $     P= H97-H55
I99 $     P= I97-I55
J99 $     P= J97-J55
G100 $     P= G99*G45
H100 $     P= H99*H45
I100 $     P= I99*I45
J100 $     P= J99*J45
G101 $     P= IF(G100>=0,G100,0)
H101 $     P= IF(H100>=0,H100,0)
I101 $     P= IF(I100>=0,I100,0)
J101 $     P= IF(J100>=0,J100,0)
G102 $     P= IF(G100<0,G100,0)
H102 $     P= IF(H100<0,H100,0)
I102 $     P= IF(I100<0,I100,0)
J102 $     P= IF(J100<0,J100,0)
G105       P= "Year 0
H105       P= "Year 1
I105       P= "Year 2
J105       P= "Year 3
G106 $     P=
H106 $     P=
I106 $     P=
J106 $     P=
G107 $     P= G55-G97
H107 $     P= H55-H97
I107 $     P= I55-I97
J107 $     P= J55-J97
G108 $     P= G56
H108 $     P= H56
I108 $     P= I56
J108 $     P= J56
G109 $     P= G98
H109 $     P= H98
I109 $     P= I98
J109 $     P= J98
G110 $     P= G108-G109
H110 $     P= H108-H109
I110 $     P= I108-I109
J110 $     P= J108-J109

SuperCalc ver.  1.10
** BENCOS ** By Ting-Ing Ho & Eric W. Crawford (Michigan State Univ.)
A111       P= "  Gross B/C Ratio =
G111 $     P= AG108/AG109
H111 $     P=
A112       P= "  Net Benefit/Scarce Resource Cost Ratio =
G112 $     P= IF(G5=1,(AG56-AG73-AG92)/AG96,ABS(AG102)/AG101)
A113 TL    P= "  Ratio of (Benefit - Prod Costs)/(Operating Cost + Capital Costs) =
B113 TL    P= "f (Benefit
C113 TL    P= "t - Prod
D113 TL    P= "Costs)/(O
E113 TL    P= "perating
F113 TL    P= "Costs +
G113 TL    P= "Capital Co
H113 TL    P= "osts) =
A114       P= "  Cost-Effectiveness Ratio =
B114       P= "fectiveness
C114 $     P= "ss Ratio
D114 $     P= "=
E114 $     P= 1/G111
F114 $     P=
G114 $     P=
H114 $     P=
C115 $     P=
D115 $     P=
E115 $     P=
F115 $     P=
G115 $     P=
H115 $     P=
```

```
A116      P= " Estimated I
B116      P= "d Internal
C116      P= "l Rate of
D116      P= " Return (
E116      P= "IRR) for
F116      P= "this Analysis
G116      P= "ysis:
H116      P=
A117      P= " Interest Rate
C117 $    P= .02
D117 $    P= .04
E117 $    P= .06
F117 $    P= .08
G117 $    P= .10
H117 $    P= .12
A118      P= " Net Present Value
C118 $    P= NPV(C117,H107:AF107)+G107
D118 $    P= IF(C118>=0,NPV(D117,H107:AF107)+G107,-9999)
E118 $    P= IF(D118>=0,NPV(E117,H107:AF107)+G107,-9999)
F118 $    P= IF(E118>=0,NPV(F117,H107:AF107)+G107,-9999)
G118 $    P= IF(F118>=0,NPV(G117,H107:AF107)+G107,-9999)
H118 $    P= IF(G118>=0,NPV(H117,H107:AF107)+G107,-9999)
A119      P= " Gross B/C Ratio
C119 $    P= IF(C118<>-9999,(NPV(C117,H55:AF55)+G55)/(NPV(C117,H97:AF97)+G97),NA)
D119 $    P= IF(D118<>-9999,(NPV(D117,H55:AF55)+G55)/(NPV(D117,H97:AF97)+G97),NA)
E119 $    P= IF(E118<>-9999,(NPV(E117,H55:AF55)+G55)/(NPV(E117,H97:AF97)+G97),NA)
F119 $    P= IF(F118<>-9999,(NPV(F117,H55:AF55)+G55)/(NPV(F117,H97:AF97)+G97),NA)
G119 $    P= IF(G118<>-9999,(NPV(G117,H55:AF55)+G55)/(NPV(G117,H97:AF97)+G97),NA)
H119 $    P= IF(H118<>-9999,(NPV(H117,H55:AF55)+G55)/(NPV(H117,H97:AF97)+G97),NA)
A120      P= '-
A121      P= " (Working Space, i
C121      P= IF(C118<>-9999,C117,0)
D121      P= IF(D118<>-9999,D117,0)
E121      P= IF(E118<>-9999,E117,0)
F121      P= IF(F118<>-9999,F117,0)
G121      P= IF(G118<>-9999,G117,0)
H121      P= IF(H118<>-9999,H117,0)
A122      P= " (Working Space,
B122      P= " Space, I
C122      P= "ower i =
D122      P= MAX(C121:AF121)-.02
E122      P= ",lowernpv
F122      P= NPV(D122,H107:AF107)+G107
G122      P= "; hi npv
H122      P= NPV((D122+.02),H107:AF107)+G107
A123      P= '-
A124      P= " The Internal Rate of Return (IRR) =
E124      P= IF(F122>=0,D122+.02*(F122/(F122+ABS(H122))),NA)
F124      P= "  or
G124 $    P= E124*100
H124      P= " PERCENT
```

```
SuperCalc ver.  1.10
** BENCOS ** By Ting-Ing Ho & Eric W. Crawford (Michigan State Univ.)
A616      P= SUM(G16:AF16)
A619      P= SUM(G19:AF19)
A622      P= "    TOTAL
A625      P= SUM(G25:AF25)
A628      P= SUM(G28:AF28)
A632      P= SUM(G32:AF32)
A635      P= SUM(G35:AF35)
A638      P= SUM(G38:AF38)
A639      P= SUM(G39:AF39)
A643      P= "    TOTAL
A645 $    P=
A646 $    P=
A647 $    P= SUM(G47:AF47)
A648 $    P=
A649 $    P=
A650 $    P= SUM(G50:AF50)
A651 $    P= SUM(G51:AF51)
A652 $    P=
A653 $    P=
A654 $    P= SUM(G54:AF54)
A655 $    P= SUM(G55:AF55)
A656 $    P= SUM(G56:AF56)
A662      P= "    TOTAL
A664 $    P= SUM(G64:AF64)
A665 $    P=
A666 $    P=
A667 $    P= SUM(G67:AF67)
A668 $    P= SUM(G68:AF68)
A669 $    P=
A670 $    P=
A671 $    P= SUM(G71:AF71)
A672 $    P= SUM(G72:AF72)
A673 $    P= SUM(G73:AF73)
A682      P= "    TOTAL
A683 $    P= SUM(G83:AF83)
A684 $    P=
A685 $    P=
A686 $    P= SUM(G86:AF86)
A687 $    P= SUM(G87:AF87)
A688 $    P=
A689 $    P=
A690 $    P= SUM(G90:AF90)
A691 $    P= SUM(G91:AF91)
A692 $    P= SUM(G92:AF92)
A693 $    P= SUM(G93:AF93)
A694 $    P= SUM(G94:AF94)
A695 $    P= SUM(G95:AF95)
A696 $    P= SUM(G96:AF96)
A697 $    P= SUM(G97:AF97)
A698 $    P= SUM(G98:AF98)
A699 $    P= SUM(G99:AF99)
A6100 $    P= SUM(G100:AF100)
A6101 $    P= SUM(G101:AF101)
A6102 $    P= SUM(G102:AF102)
A6105      P= "    TOTAL
A6106 $    P=
A6107 $    P= SUM(G107:AF107)
A6109 $    P= SUM(G108:AF108)
A6109 $    P= SUM(G109:AF109)
A6110 $    P= SUM(G110:AF110)
```

Annex 3: Addendum to User's Guide to BENCOS, by Ting-Ing Ho and A. Allan Schmid

1. Introduction

These instructions describe an addendum to the BENCOS template written by Ting-Ing Ho and Eric Crawford, and are in addition to the instructions prepared for BENCOS. The addendum adds compounding calculations to the present value and IRR calculations of BENCOS. It is useful for showing the sensitivity of a project's rank (when compared to other projects) to a wider variety of investment criteria. It also provides data for the "Terminal Value Method (Mishan, 1976 and Schmid, 1983) which explicitly transforms project cash flows to reflect explicit reinvestment assumptions. Different discount rates can be applied to costs and benefits.

2. Description of Amended BENCOS (File name SCHMID)

The amended BENCOS template has everything that the original template had (with minor exceptions) plus an addition to the parameter section and a new output section for the compounding results.

2.1 Parameter Section

In addition to the previous program's parameters, the following parameters are to be entered (cell coordinates J3:P5): (a) terminal year, i.e., the last year of data for the longest lived project being compared; and (b) interest rates for compounding (can be different for benefits and costs).

2.2 Data Input Section (rows 14-39)

Same as for BENCOS (see user's guide).

2.3 Output Section (rows 44-159)

Lines 129-130 show the compounding factor $(1+r)^n$ for each year. Subsequent lines show the calculated terminal value for benefits and various types of cost.

Line 136 is the Terminal Value of Excess of Cost over Return for each year. Any positive value in line 136 indicates a capital requirement (in effect a need to borrow). The total column for line 136 (cell AG136) indicates the Terminal Value of Net Benefit, which is the same as cell G140 (with a sign change).

Three terminal value ratios are calculated: (141) Gross Terminal B/C Ratio (with all types of cost considered as limiting), (142) Net Benefit/Scarce Resource Cost Ratio (with only costs designated in parameter section as limiting), and (143) Ratio of (Benefit - Production Costs)/(Operating Costs + Capital Costs) with operating and capital cost regarded as limiting.

Rows 146-151 express the terminal values as present values. That is, the terminal value in Year T is discounted to the present by the factor $1/1+r)^T$. This is included so it can be demonstrated that <u>if</u> values are compounded and then discounted at the <u>same rate</u>, the results are the same as the original present value (i.e., Row 146 = Σ Row 108; 147 = Σ Row 109; and the B/C ratios are equal, e.g., Row 148 = row 111). The same holds for NPV (row 150 = Σ row 110).

Rows 152-159 are concerned with computing a special kind of IRR wherein the cost of capital and net returns are discounted (compounded) at explicitly selected rates. Following Mishan (1976, Ch. 37), it is called the "normalized internal rate of return". The sum of line 138 (cell AG138) is the terminal value of net return (TVR), obtained by compounding at a selected rate to the selected terminal year, i.e., the sum of the values in years when net cash flow is positive. (Don't be confused by the fact that the program shows these values as negative.) The sum of line 101 (cell AG101) is the present value of

net investment (i.e., capital cost (K)) discounted at a selected rate, i.e., the sum of the values in years when net cash flow is negative (actually shown as positive numbers). The normalized IRR then is the rate of interest which makes the terminal value of net returns equal to the present value of net investment (K). I.e., the normalized IRR is the rate of interest which reduces the following transformed net cash flow stream of line 139 to zero: -K, 0, 0, ..., TVR. It represents the average rate of growth over years of an initial sum K (or present value of K) that will yield a given terminal sum. This calculated normalized IRR of the explicitly reconstructed net cash flow is shown in line 159. (Note that if the IRR is negative, the value shows as N/A.).

Note: Remember that in G format numbers will be shown in scientific notation when they are too large for the column. When the Terminal Value of Net Benefit is <1 the program is written so that it will show the value approaching zero (carried to many places). This will be printed in scientific notation as a number with a large negative exponent such as 8.7e-12.

3. How to Use the Amended BENCOS

3.1 Loading the Template

After loading SuperCalc, load the amended BENCOS template by entering command /L, SCHMID, A. (enter /L, followed by SCHMID (hit enter), followed by A.

3.2 Entering Parameters and Data

Follow the directions in the main BENCOS user's guide. After data is entered, hit [!] to calculate. Note: relative to Step 6 (2) in the

original guide: to obtain a summary of the most needed information (rows 106-159) enter the following commands:

/O, D, A106: H159, P

Then depending on the number of years used (terminal year) you can print the needed values by putting the column letter for the last needed year after the semi-colon (up to 8 more columns), for example a 3-year comparison:

/O, D, I106: J159, P

or whatever you need following the same general instructions in the original guide.

4. Making Comparisons

Write down or print out the necessary results for the project analyzed and repeat for other projects being compared. The parameters and data input from the first project can be cleared by:

/B, A1: AG40

Do not blank or zap everything or your headings will disappear and you will have to load the program again.

The data in the parameters section can be changed as needed. Remember that the compounding parameter entry cells are to the right of what shows originally on the screen.

5. On rare occasions, the output may be printed in the wrong column because of the limited memory of SuperCalc. (Sorcim has informed us that problems associated with very large spreadsheets have been rectified in SuperCalc2.) Check rows 108-110 to see if the percentages are all in the same column. If not, recalculate and hope that it is right next time.

Annex 3: Terminal Value Spreadsheet

```
  |  A  ||  B  ||  C  ||  D  ||  E  ||  F  ||  G  ||  H  ||  I  ||  J  ||  K  ||  L  ||  M  ||  N  |
1|                                                                  SUMMARY OF BENEFIT-COST ANALYSIS
2|PARAMETERS SECTION
3| Planning Horizon =              >>        <<  years                        Terminal Year =                          >>
4| Interest Rate for Discounting =  >>        <<  (Enter a decimal value)      Interest Rate for Compounding Costs =    >>
5| Definition of Capital or Scarce Resource Costs =   >>        <<           Interest Rate for Compounding Benefits =  >>
6|   (1: as entered in rows 38 & 39)
7|   (2: excess of cost over return, row 99)    ~
8|~~~
```

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WP No. 14	Eric W. Crawford, Ting-Ing Ho, and A. Allan Schmid, "User's Guide to BENCOS—SuperCalc Template for Benefit-Cost Analysis," 1984 (35 pp.).	$ 3.00
	Copy of BENCOS Template in IBM PC-DOS 1.1 Format, on single sided double density diskette (readable on most MS-DOS systems).	$15.00
WP No. 15	James W. Pease and Raoul Lepage with Valerie Kelly, Rita Laker-Ojok, Brian Thelen, and Paul Wolberg, "An Evaluation of Selected Microcomputer Statistical Programs, 1984 (187 pp.).	$ 7.00