A Computer Program to Provide Present Value Assessment of Future Income and Costs Streams

Wallace E. Killcreas
John E. Waldrop

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A COMPUTER PROGRAM TO PROVIDE
PRESENT VALUE ASSESSMENT OF FUTURE
INCOME AND COSTS
STREAMS

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Department of
Agricultural Economics
A COMPUTER PROGRAM TO PROVIDE PRESENT VALUE
ASSESSMENT OF FUTURE INCOME AND COSTS STREAMS

By

Wallace E. Killcreas and John E. Waldrop

Introduction

The purpose of this report is to provide and describe a computer
program for determining present values (discounted future values),
capitalized values, and net annual equivalent values of regular or
irregular streams of incomes and costs over a definable future time
period. Also, where appropriate, this program will estimate the in-
ternal rate of return.

The computer program described herein is applicable to all dis-
ciplines that might be concerned with comparison of costs and returns
among alternative investment opportunities. Examples drawn from agri-
cultural economics and forestry are presented to illustrate the appli-
cation of the concepts and the use of the program.

Discounting

In estimating the present value of future returns, one is con-
fronted with the problem that income to be collected in some future
period has less utility than income collected today. One way to resolve
this problem is to discount future returns to the present. A formula
which accomplishes discounting is:

(1) \[ \text{Gross Value at year } k = \frac{\text{Return at year } i}{(1 + r)^{i-k}} \]

where \( r \) = discount rate expressed as a decimal.
If income is expected to occur annually over some finite period of years, the annual incomes can be discounted in this manner and then summed to obtain the present value of the expected income stream. Incomes are assumed to occur at the end of each year (year 1 is discounted).

Most activities which produce future income streams also incur some costs. These costs may be the same each year, or they may vary. Costs can also be discounted by using the formula expressed in (1). Costs are assumed to occur at the beginning of each year (year 1 is not discounted).

Putting discounted future dollar returns and costs together yields a net present value:

(2) Net Present Value = Discounted Returns - Discounted Costs

The net present value may be estimated prior to incurring costs or receiving revenues (year 0), or at some period within the life of the activity (year k). In forestry applications, the optimum length of timber rotations may be the problem under study. In such cases, the present value of alternative rotation lengths repeated in perpetuity can be compared to determine the rotation length that yields the highest value. On the other hand, the problem may involve a stand of trees that are currently 30 years of age (k = 30), for which the optimum rotation is 35 years and we wish to compare the liquidation value of the standing timber to the present value of the 35 year rotation.
Capitalization and Annual Equivalents

Many processes can be thought of as producing income in perpetuity, rather than for a finite number of years. For such situations it is useful to compute a capitalized value. The capitalized value of an asset or resource is the present value of all future incomes and costs that accrue to that asset or resource in perpetuity. It, therefore, is an estimate of the investment value of the asset.

Equation (3) may be used to calculate the capitalized value of an asset or resource that yields net returns that are equal over time and are regular in time (e.g., annual net returns of $20 per acre).

\[(3) \text{ Capitalized value} = \frac{R}{r}\]

where \(R\) is the regular (annual) net return and \(r\) is the appropriate discount rate.

A formula for situations where the income and cost flows are irregular in amount and/or in time is as follows:

\[(4) \text{ Capitalized Value} = \sum_{i=1}^{n} \frac{R_i}{(1 + r)^{n-k}} \left[ \frac{(1 + r)^{n-k}}{(1 + r)^{n-k-1}} \right]\]

where \(R_i\) = net return that occurs in the \(i^{th}\) period of the activity
\(r\) = discount rate expressed as decimal
\(n\) = the number of years over which \(R_i\) is analyzed
\(k\) = is the base year (usually zero)

If there is some current market value \((Z)\) it may be entered as a separate value in the analysis. A nonzero current market value implies a nonzero base year (see header card on page 6).
Rearranging equation (3) allows capitalized values to be converted to annual equivalents:

(5) Annual Equivalent = r (Capitalized Value)

since an annual equivalent is an annual income over a defined future period.

Internal Rate of Return

An area of interest to those who borrow, lend, and allocate money is that of determining the compound rate of return from their investment. This value, defined as the internal rate of return, is the discount rate that causes the sum of future net returns to equal the initial investment cost. Determination of the internal rate of return is available in this computer program, provided that future income and costs flows can be estimated, and the amount of the proposed investment is known.

If the present liquidation value of an asset is to be compared to a single expected future value (net return assuming the asset is left in place), the internal rate of return can be computed directly.

Consider:

(6) \[ PV = \frac{FV}{(1 + r)^n} \]

.....where PV is the present (liquidation) value of the asset
FV is the estimated future value of the asset
n is the year in which the estimated future value is available

.....and r is the internal rate of return.

Rearranging (6) yields:

(7) \((1 + r)^n = \frac{FV}{PV}\)
Taking logarithms of (7) yields:
Log \((1 + r)\) = Log \((FV/PV)/n\)
and (8) \(r = (\text{antilog} \,(FV/PV)/n)-1\)

If multiple incomes and costs that are different in amount and in time of occurrence are to be evaluated, the calculations outlined in equations (6) through (8) are not applicable.

However, when an expected income flow generates some initial costs which must be offset by the income flow (this is commonly the situation when evaluating a potential investment in any durable good), a discount rate can be chosen such that the net present value of the cost and income stream approaches zero. Consider:

\[
\text{(9) net PV} = n \sum_{i=1}^{n} \left[ \frac{FV_i}{(1 + r)^n} - \frac{C_i}{(1 + r)^{n-1}} \right]
\]

.....where \(FV_i\) is an income flow, \(C_i\) is a costs flow, and all other variables are as previously defined.

If a discount rate \(r\) is chosen such that net PV approaches zero, the discount rate \(r\) approaches the internal rate of return associated with the investment.

An iterative scheme was used in this program to solve (9) for the internal rate of return to the nearest 1/10 of one percent. Internal rate of return calculations are not appropriate for problems in which an initial investment is not made.

Computer Program

This computer program is designed to provide present values, capitalized values, and annual equivalent values for a series (irregular or
regular) of costs and returns to base year 0, or to nonzero base year k. Up to 99 years may be chosen as a discounting period for the computations, and up to 10 discount rates may be used. Also, the internal rate of return can be calculated where appropriate.

This program will solve as many discounting problems as desired each time it is executed. Each discounting problem should consist of a header card containing information relating to the problem at hand, N data cards containing estimated future costs and/or income values, and a problem trailer card. (Trailer cards are needed only when multiple problems are to be solved during one program execution). A user's guide to the program and four example problems are presented below, and a program listing is provided in the Appendix.

User's Guide

All numerical data inputs should be right-justified with leading blanks. Integers should not contain decimal points and floating point data (dollars and cents, for example) would usually have decimals punched.

A. Header Card

<table>
<thead>
<tr>
<th>Columns</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-12</td>
<td>Alphanumeric identifier for the problem. Free form.</td>
</tr>
<tr>
<td>14-15</td>
<td>Discounting period. The year in the future at which the discounting analysis will end. Values between 1 and 99 may be coded. If the base year is zero, this value is the planning horizon. Integer, required.</td>
</tr>
<tr>
<td>16-17</td>
<td>Base year. Zero for most problems. Problems involving resources already in place would require that values greater than zero be coded. Integer, optional. If omitted, zero is assumed.</td>
</tr>
</tbody>
</table>
18-27 Liquidation value of the resource being analyzed. If the base year is zero, the liquidation value would also be zero. If a resource is already in place, it will usually have a positive liquidation value. Floating point, optional. If omitted, zero is assumed.

28 Y if internal rate of return is to be computed, otherwise blank. This field should be coded only if an investment has been made in year 1.

29-30 Number of discount rates. Right justified integer value between 1 and 10. Required.

31-35 First discount rate expressed as a decimal fraction. At least one discount rate is required. Floating point. If no decimal is punched, 4 digits to the right of the implied decimal will be assumed.

36-40, 41-45, etc. Second through ninth discount rates (optional).

76-80 Tenth discount rate (optional).

B. Cost and income flow data cards -- As many cost and income data cards may be coded as desired. Each cost/income data card corresponds to an expected future cost or income for one of the years in the future under analysis.

<table>
<thead>
<tr>
<th>Columns</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blank</td>
</tr>
<tr>
<td>2-3</td>
<td>Future year to which this cost or income pertains. Integer, required. This analysis is couched on the beginning of the year specified (i.e., year 1 would not be discounted) for costs, and the end of the year (i.e., year 1 is discounted) for revenues.</td>
</tr>
<tr>
<td>4-5</td>
<td>Number of years a cost/revenue is to be repeated. The year coded in columns 2-3 would be repeated for as many years as specified. If this field is left blank, the cost/revenue will be applied to the year specified in columns 2-3 only.</td>
</tr>
<tr>
<td>6-15</td>
<td>Cost (if any) associated with the year coded in 2-4.</td>
</tr>
<tr>
<td>16-25</td>
<td>Revenue (if any) associated with the year coded in 2-4.</td>
</tr>
</tbody>
</table>
C. Trailer Card -- Needed only if more than one analysis if to be performed.

1-3 END

If a data card is encountered following the END card, it will be interpreted as a header card for the next analysis.

Example Problems

Introduction

There are four problems presented. Problems 1 and 2 relate to forestry investments at different time intervals along a timber rotation. Problem 3 is designed to aid a decision maker in deciding whether or not to purchase a durable good. Problem 4 is concerned with calculating the internal rate of return. (The internal rate of return calculation is also pertinent to problem 3).
Example Runstream For Four Problems

A complete runstream to solve the four sample problems follows. It is pertinent to UNIVAC 1100 systems only. The data coded after the @XQT statement would be exactly the same on any computer system.
Column numbers are coded for the readers' convenience. Line numbers will be referenced in all explanations.

**Forestry examples** - Problems 1 and 2 relate to land use decisions for timber growing enterprises. The same stream of costs and revenues relative to one acre of land was used in both examples.

In problem 1, a land use decision relative to "bare land" is to be made. Costs and income flows are available at various future dates. This analysis assumes no establishment costs, a 50 year rotation, and interest rates of 5%-12%.

Data inputs needed for the analyses are defined in cards 10-21 of the example runstream. Results from this analysis are:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RATE</th>
<th>PRESENT VALUE</th>
<th>ANNUAL EQUIVALENT</th>
<th>CAPITALIZED VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>.0500</td>
<td>671.3370</td>
<td>36.7737</td>
<td>735.4730</td>
</tr>
<tr>
<td>0</td>
<td>.0600</td>
<td>494.2904</td>
<td>31.3599</td>
<td>522.6650</td>
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<td>.0700</td>
<td>369.1136</td>
<td>26.7459</td>
<td>382.0847</td>
</tr>
<tr>
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<td>.0800</td>
<td>279.2618</td>
<td>22.9277</td>
<td>285.3456</td>
</tr>
<tr>
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<td>.0900</td>
<td>165.9269</td>
<td>14.3146</td>
<td>210.7455</td>
</tr>
<tr>
<td>0</td>
<td>.1000</td>
<td>129.4277</td>
<td>10.2969</td>
<td>166.9547</td>
</tr>
<tr>
<td>0</td>
<td>.1100</td>
<td>102.1200</td>
<td>12.2969</td>
<td>102.4745</td>
</tr>
</tbody>
</table>

**Problem 1:** Forestry rotation or capitalization year is 50
Notice that the annual equivalent for an interest rate of 8% is $22.83. This means that, based on the costs and income flows above, if the landowner invested $22.83 each year for 50 years at 8%, at the end of 50 years he would have an income equivalent to the return from one acre of the forest enterprise. Notice that some of this income is available as early as year 18 of the rotation. If a competing land use such as soybeans could net more than $22.83 per year over the same planning horizon, it would be preferred (assuming the same amount of risk for both enterprises).

In example 2 (cards 22-33 of the example runstream), the same income/costs flow is assumed, but 17 years of the rotation have passed. A very small liquidation value of $50 per acre is assumed, since the stand is assumed to be at a preoptimal stage of development. Output from this example is presented below.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RATE</th>
<th>INCOME</th>
<th>COSTS</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>.0600</td>
<td>93.5341</td>
<td>93.5341</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>.0700</td>
<td>91.4208</td>
<td>91.4208</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>.0800</td>
<td>87.4325</td>
<td>87.4325</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>.0900</td>
<td>86.6979</td>
<td>86.6979</td>
<td></td>
</tr>
<tr>
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<td>.1000</td>
<td>86.1866</td>
<td>86.1866</td>
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</tr>
<tr>
<td>17</td>
<td>.1100</td>
<td>788.1625</td>
<td>788.1625</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>.1200</td>
<td>716.2231</td>
<td>716.2231</td>
<td></td>
</tr>
</tbody>
</table>
Notice that the 8% annual equivalent value from years 17-50 has increased to $89.74 per acre per year! In order for some alternative land use enterprise to replace the forest resource that has been in place for 17 years, it must offer more than $89.74 per acre per year over the remaining forest rotation. These two examples point out how different the analysis can be when resources are already in place.

Internal Rate of Returns Examples - In example 3, suppose a farmer is attempting to determine whether or not he can afford to add another 4-row tractor to his operation. He estimates that it will net $4,500 per year (1978 dollars) to his operations for 12 years. Notice that in this example (see example runstream cards 34-37) the $4,500 income is repeated for the 12 year assumed life of the tractor (see card 36 of example runstream, cols 4-5). The analysis follows.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>INCOME</th>
<th>COSTS</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4500.00</td>
<td>28500.00</td>
<td>1</td>
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<td>1</td>
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<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4500.00</td>
<td>0</td>
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<tr>
<td>3</td>
<td>4500.00</td>
<td>0</td>
<td>4</td>
</tr>
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<td>4</td>
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<td>5</td>
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<td>0</td>
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</tr>
<tr>
<td>6</td>
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<tr>
<td>11</td>
<td>4500.00</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

INTERNAL RATE OF RETURN LIES BETWEEN 11.5% AND 11.6% COMPOUND RATE.

PROBLEM: 3. TRACTOR ROTATION OR CAPITALIZATION YEAR IS 12

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RATE</th>
<th>PRESENT VALUE</th>
<th>ANNUAL EQUIVALENT</th>
<th>CAPITALIZED VALUE</th>
</tr>
</thead>
<tbody>
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<td>8214.2637</td>
<td>1006.8073</td>
<td>15489.3423</td>
</tr>
<tr>
<td>0</td>
<td>.0700</td>
<td>7242.0887</td>
<td>911.7934</td>
<td>13025.6202</td>
</tr>
<tr>
<td>0</td>
<td>.0750</td>
<td>6304.7936</td>
<td>815.5621</td>
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<tr>
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<td>.0800</td>
<td>5412.3506</td>
<td>718.1919</td>
<td>8977.3994</td>
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<td>.0850</td>
<td>4551.6878</td>
<td>619.6436</td>
<td>7289.9250</td>
</tr>
<tr>
<td>0</td>
<td>.0900</td>
<td>3725.2948</td>
<td>519.9564</td>
<td>5777.2935</td>
</tr>
<tr>
<td>0</td>
<td>.0950</td>
<td>2927.2767</td>
<td>419.1501</td>
<td>4412.1059</td>
</tr>
<tr>
<td>0</td>
<td>.1000</td>
<td>2161.6131</td>
<td>317.2455</td>
<td>3172.4551</td>
</tr>
</tbody>
</table>
Notice that the internal rate of return (card 34, col. 28) was computed at 11.5% to 11.6% compound rate. If the farmer can borrow money at interest rates up to the estimated internal rate of return, he can justify making the investment.

In example 4, a costs/income stream was available to estimate the value of doing research in the area of rice production. Seventeen years of data were available (see cards 38-52 of example runstream). Next the analysis:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RATE</th>
<th>INCOME</th>
<th>COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
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<td>32287.00</td>
<td>32287.00</td>
</tr>
</tbody>
</table>

**INTERNAL RATE OF RETURN LIES BETWEEN 16.9% AND 17.0% COMPOUND RATE.**

**PROBLEM: 4. RICE**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RATE</th>
<th>PRESENT VALUE</th>
<th>ANNUAL EQUIVALENT</th>
<th>CAPITALIZED VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>121861.1543</td>
<td>121861.1543</td>
<td>173803.1875</td>
</tr>
<tr>
<td>0</td>
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<tr>
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<td>101361.7462</td>
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<td>92089.6309</td>
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<tr>
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</tr>
<tr>
<td>0</td>
<td>.1000</td>
<td>67687.1826</td>
<td>67687.1826</td>
<td>82531.1328</td>
</tr>
</tbody>
</table>

The internal rate of return computed indicates that over the years for which estimates of costs/income flows are available, the payoffs from agricultural research in rice is high.
Summary

This report provides and describes a computer program to calculate present values of future income and cost flows. The present values may appear in the form of capitalized values, and/or annual equivalent values. This program will also estimate the internal rate of return, where appropriate.

These analytical procedures have wide application. Four examples were included to illustrate some common uses. Many other problems can be structured to fit the analysis scheme of the computer program reported. The decision to define problems so that they may be solved without changes to the program or decisions to modify the computer program to solve problems that do not fit our format is left to users.
APPENDIX

A listing of this program follows. The program should be compatible with computer systems other than the UNIVAC 1100 series system on which it was developed.
APPENDIX --- LISTING OF Discounting COMPUTER PROGRAM

```plaintext
DIMENSION R(10),VAL(10,3),XINC(100),COST(100),NXID(2),ITEMP(13),
* X2(100),C2(100),ID(2)
DATA TBLANK/*1/**
1 IF??=$E 0
  DO 76 I=1,100
  C2(I)=0.
  X2(I)=0.
  COST(I)=0.
  XINC(I)=0.
  DO 77 J=1,10
  VAL(I,J)=0.
  DO 77 J=1,10
  READ(5,10)I0,M,K,Z,IRR,N,(R(I),I=1,N)
  IF(LAT<(I),E0,'END')GO TO 2
  READ(0,12)LYX,LUK,COSTS,REVNU
  FORAT(II.12,2F10.0,A1.12,10F5.4)
  IF(LYX.LT.0 OR. LYT.GT.100)GO TO 14
  IYX=LYX
  IF(UDW.LE.10)GO TO 48
  IF(UDW+I YX.GT.100)GO TO 48
  IF(UDW=LYX)GO TO 14
  CONTINUE
  GO TO 14
  READ(0,10)NAID
  IF(NXID(I),LE.'END')GO TO 19
  GO TO 14
  WRITE(6,1710)
  IF(1<1.0)K=1
  DO 16.1=K,M
  WRITE(6,16JXINC(I))COST(I),
  IF(NXID(I),LE.'END',XINC(I)=0)
  IF(XINC(I))XINC(I)+COST(I)
  CONTINUE
  IF(INTERNAL RATE OF RETURN IS GREATER THAN 100%*) GO TO 26
  PV=1
  DO 44 J=1,100
  IF(1<1.1=KK,M
  DO 23 J=1
  IF(IRR. LE.10)GO TO 26
  IF(IRR.GE.100)GO TO 26
  PV=PV+(X2(I)/(1.+J/100.)***(1-J))-(C2(I)/(1.+J/100.)***(1-K))**I
  CONTINUE
  IF(PV.LE.0)GO TO 40
  CONTINUE
  WRITE(6,41)
  FORMAT('INTERNAL RATE OF RETURN IS GREATER THAN 100%')
  GO TO 26
  I=(1-J)*10+1
  JJ=J=9
  DO 44 J=1,9
  PV=0.
  DO 45 I=1,100
  X2(I)=X2(I)/(1.+X)***(1-J)-(C2(I)/(1.+X)***(1-K))**I
  PV=PVP+X2(I)/(1.+X)***(1-J)-(C2(I)/(1.+X)***(1-K))**I
```

APPENDIX --- LISTING OF DISCOUNTING COMPUTER PROGRAM

46 CONTINUE.
44 IF(PV.LE.0) GO TO 400
400 X=(J-1)/10^4
YY=J/10^6
WRITE(6,43)XX,YY
42 FORMAT('INTERNAL RATE OF RETURN LIES BETWEEN ',F5.1,'% AND ',F5.1

+%' COMPOUND RATE.' )
WRITE(6,43)DM
33 FORMAT(11H0,'PROBLEM: '2A6 ' ROTATION OR CAPITALIZATION YEAR IS'

1,16)
IF(Z.GT.0) WRITE(6,34)Z
34 FORMAT('0',1X,'INITIAL ASSESSED VALUE, EXCLUSIVE OF FUTURE RETURNS IS'

1,16)
WRITE(6,34)Z
35 FORMAT(11H0,'6X,'HATE',1X,'PRESENT VALUE',3X,'ANNUAL EQUIVALENT'

+3X,'CAPITALIZED VALUE'/)
WRITE(6,35)
DO 24 J=1,N
VAL(J,5)=(VAL(J,1)+(1+R(J))**(M-K))/((1+R(J))**(M-K)+1)RCAP.VALUE
VAL(J,2)=VAL(J,3)*R(J) ANNUAL EQUIVALENT
WRITE(6,25)K,R(J),VAL(J,3),K=1+3)
25 FORMAT('3X,14F10.4,3F20.4)
24 CONTINUE.
IF(END.EQ.1) STOP GOOD
IFLAGE=0
GO TO 1
30 IF(FLAG.EQ.0) STOP GOOD
GO TO 19
END

@FIN
SELECTED BIBLIOGRAPHY


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In conformity with Title IX of the Education Amendments of 1972 and Section 504 of the Rehabilitation Act of 1973, Dr. T. K. Martin, Vice President, 610 Allen Hall, P. O. Drawer J, Mississippi State, Mississippi 39762, office telephone number 325-3221, has been designated as the responsible employee to coordinate efforts to carry out responsibilities and make investigation of complaints relating to nondiscrimination.