

# Developments In Business Simulation & Experiential Exercises, Volume 21, 1994

## INCREASING THE EFFECTIVENESS OF PERFORMANCE EVALUATION THROUGH THE DESIGN AND DEVELOPMENT OF REALISTIC FINANCE ALGORITHMS

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### ABSTRACT

This paper examines the current status of business enterprise simulations regarding the question of whether those simulations being used employ a finance algorithm based on modern cost of capital concepts. Having found that most current simulations are based on outmoded market value per share concepts, the authors present a complete finance model based on modern cost of capital and capital structure concepts.

### INTRODUCTION

In general management or business enterprise simulations, students often assume that the major goal is to generate net income. Administrators of simulations often evaluate performance and awards grade points in terms of how teams rank according to net income. The assumption is often made that the teams with the greater net incomes are the better decision-makers. However, using net income as the sole criterion of performance can be fraught with misleading implications. Teams with equal net incomes can easily have different rates of return and market values per share. In many cases, it may be desirable to evaluate simulation results in terms of optimal capital structure, optimal market value, and optimal cost of capital. However, in order to use these financial measures a fairly sophisticated and realistic finance algorithm is needed.

In collegiate schools of business, general management or business enterprise simulations are more popular and widely used than the functional marketing and finance simulations. The two primary components of simulations, the computer program and the student manual, contain three primary segments that are commonly called marketing, production and finance- Consequently, decisions are commonly classified as marketing, production, and financial. Each of these types of decisions requires special processing algorithms. From a modeling or design viewpoint, the marketing and production segments continue to be the focal points of simulation design research (Carvalho, 1990; Gold, 1992; Goosen, 1993; Thavikulwat, 1992; Teach, 1990). However, the modeling of the finance segment appears to be a neglected area of simulation research -

Beginning in the early 1960's and for several decades following, important advances in financial theory were being made that challenged some long held cost of capital views. Significant new models explaining cost of capital and firm value were presented. At the same time, computerized general management simulations were being developed and used. The authors of this paper were concerned that the older simulations may still be based on outdated cost of capital concepts. In addition, there was concern that the newer simulations developed in the past ten years also might be based on the same type of simplistic finance algorithms.

Our concerns led us to investigate existing simulation to determine whether simulations in current use are based on finance algorithms that (1) use a constant cost of equity capital independent of the debt/equity ratio, (2) use a constant interest rate on new debt independent of the debt/equity ratio, and (3) compute market value per share ignoring the growth rate in net income per share.

We also suspected that the simulation literature might be void concerning articles dealing with how to develop finance algorithms

that incorporate the new developments in cost of capital literature. This later suspicion was confirmed when a literature check was made of all articles in *Simulation and Gaming* and ABSEL proceedings. No articles were found that directly or indirectly addressed the question of how to develop computerized finance algorithms based on modern cost of capital concepts. How simulations designers model the complex cost of capital issues is a well kept secret.

Financial theorists have proposed that the major purpose of management is to make decisions that maximize stockholders' value. In order to evaluate performance based on maximized stockholders' value, a computer simulation model that processes the necessary interrelated financial variables is required. A workable model based on current finance theory means that in addition to net income, market value per share, optimal capital structure, and optimal cost of capital can be used as performance measures.

Consequently, the primary purpose of the paper is to present an algorithm solidly based on modern finance theory that will generate a realistic per share market value. Prior to presenting this model, two basic questions will be addressed: (1) To what extent do current general enterprise simulations models adequately model the finance function? and (2) What elements and variables are necessary to model the finance function as set forth in current finance literature?

### REVIEW OF FINANCE ALGORITHMS IN CURRENT SIMULATIONS

Keys (1987) compared the ten leading total enterprise simulations on the basis of marketing, production, and financial variables (decisions). His comparative analysis revealed that only four out of the ten simulations reviewed allowed the issue of bonds. A detailed questionnaire was sent to all authors of those simulations reviewed by Keys. Since six out of the ten simulations reviewed by Keys did not allow the substitution of stock with debt, the absence of modern finance theory in these simulation was obvious. Of the four simulations indicated by Keys to have the potential for debt/equity decision-making, three responses were received from the authors of these simulations. Analysis of these responses indicated that in only one of the three simulations did the finance algorithm contain the necessary variables and decisions for implementing modern cost of capital theory. Thus based on the comparative analysis by Keys and the authors own survey of published simulations, the employment of modern finance theory in enterprise simulations indeed is absent in most instances. Based on these findings, then any meaningful attempt to evaluate simulation results in terms of maximization of shareholders' value would be futile in most cases.

### PURPOSE AND NATURE OF THE FINANCE ALGORITHM

In a general enterprise simulations, the marketing, production and finance function serve distinct purposes- The marketing algorithm must be based on one or more demand functions that incorporates interrelated variables such as price and advertising. The end product of the marketing algorithm is the distribution of units sold to each competing company. The purpose of the production function is to process decisions that determine the capacities to manufacture and from the available production resources compute units manufactured. The production function must properly process decisions such as overtime, purchase of material, number of factory workers hired, available and new equipment.

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The finance algorithm or processing module comes into play after the appropriate marketing and production values have been generated. The finance algorithm must compute:

1. Net cash flows
2. Balance of the cash account
3. Ending balances sheet and income statement balances
4. Cost of equity capital
5. Cost of debt capital
6. Market value per share

The computation of cash flows are basic and fairly routine. One of the essential and perhaps the most important purpose of the finance algorithm is to compute market value per share. This value when evaluated in light of current theory must be realistic and capable of being used as a measure of financial performance.

A major problem that confronts simulations developers is that they must choose from various available cost of capital theories ranging from the very simple to highly complex. Typical of the latter are models proposed by Miller and Modigliana (1961) and Gordon (1963). Different theories cannot be simultaneously implemented. The ideal algorithm is one that is flexible so that with only a few parameters changes different cost of capital theories may be implemented. To a considerable extent, the proposed finance algorithm in this paper possesses this flexibility.

Results in business simulations can be dynamic and unpredictable. Consequently, the finance algorithm in a simulation must be able to process decisions under a wide range of conditions, which can quickly change. Theories of capital structure and cost of capital tend to be based on assumed conditions of stability and predictability. Also, the assumption of "other things equal often prevail. The ceteris paribus assumption tends to limit the usefulness of some financial models as working algorithms within computerized general enterprise simulations. In developing the current algorithm, the authors had to find solutions for problems that arose because of the removal of the ceteris paribus assumption. For example, the proposed model allows for concurrent changes in growth in net income per share and the debt/equity ratio.

### BASIC ELEMENTS AND VARIABLES OF A FINANCE ALGORITHM

The design and implementation of a workable finance algorithm requires that the important financial elements must be (1) identified and (2) that the relationships among these variables be established. The following statements summarize the major points of theory relevant to the development of an effective market value per share algorithm:

- A major financial objective is to maximize shareholders' value (firm value).
- Shareholders' value is maximized when the weighted average cost of capital (WACC) is minimized.
- The cost of equity capital is a direct function of the debt/equity ratio.
- Increases in the debt/equity ratio will cause the cost of equity capital to rise.
- With increases in the debt/equity ratio, a point will be reached where the interest rate on debt will rise.
- The growth rate in net income is a factor in the determination of the market value per share. Investors will estimate future net income, and discount these amounts by using their required rates of return on equity.

The above-summarized statements are standard fare in most corporate finance textbooks. (E.g., see Ross, 1993). Also, excellent

reading books on current finance theory have developed by Weston (1967) and Smith (1990). The major areas of disagreement in theory pertain to the effect of leverage on the market value of the firm and the importance of dividend payments on the market value of stock.

Based on these major tenets of cost of capital theory, the following variables are important market value per share determinants:

Bond rate of interest	Tax	rate
Debt/Equity ratio	Number of shares of stock	
Cost of equity capital	Growth rate of net income	
Net income before taxes	Dividend policy	

In order to develop a workable finance algorithm, the relationships among these values must be understood. These relationships once understood and defined then must be converted to a series of sequential calculations. The diagram presented in Figure 1 illustrates the important variable relationships and required calculations. This schematic of the finance algorithm consists of four major steps:

- Step 1. Establishing the functional relationships between the debt/equity ratio and the cost of debt and equity capital.
- Step 2. Computing net operating income and net income.
- Step 3. Computing current and future net income per share.
- Step 4. Computing market value per share.

### PROCEDURES FOR DEVELOPING A MARKET VALUE PER SHARE ALGORITHM

The major objective of this section is to develop a finance algorithm capable of being imported into any computer simulation program. To accomplish this objective the required implementation steps will be carefully outlined and mathematically defined. A computer program containing the complete model is presented in the appendix.

#### Step 1 Establish Debt and Equity Capital Functional Relationships

The foundation of any market value per share algorithm must be two mathematical functions, which define the relationship of the cost of debt and equity capital to the debt equity ratio. Excellent graphical illustrations of these two important cost of capital relationships can be found in various finance textbooks (E.g., Ross, 1993). The relationships can be developed and implemented in a non mathematical way by following Goosen and Kusel's (Goosen, 1993) interpolation method as show in Figure 2.

Based on the graphs in Figure 2, linear range data points were selected and them used to create interpolation schedules as follows:

Debt/Equity Ratio	Cost of Debt Capital	Cost of equity Capital
1 .1111	.8000	.1200
2.1250	.0820	.1210
3.4333	.0840	.1220
4.6667	.0880	.1230
5 1.0000	.0910	.1260
6 1.5000	.0960	.1300
7 2.3330	.1020	.1400
8 4.0000	.1200	.1600
9 9.0000	.1800	.2350
10 10.0000	.2600	.2700

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Figure 1. Diagram of Proposed Finance Algorithm

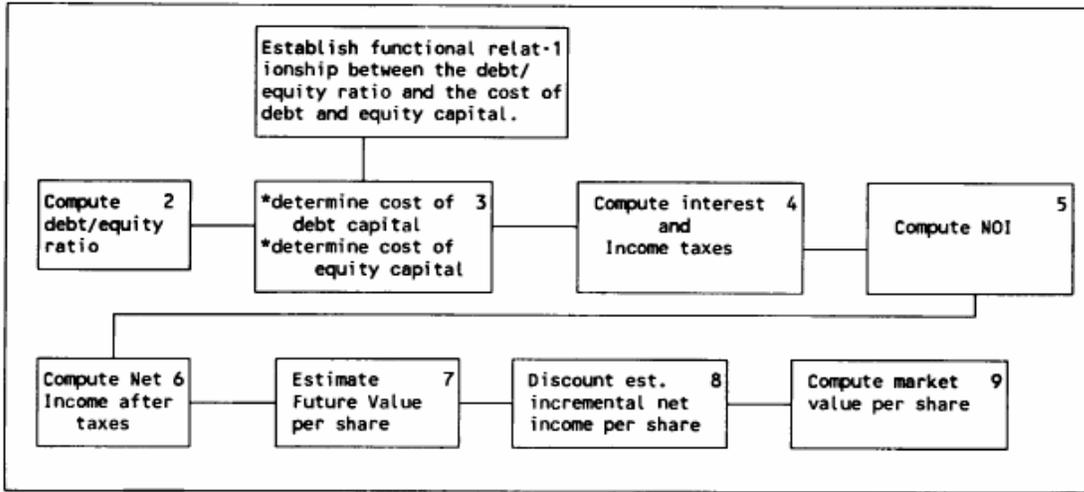
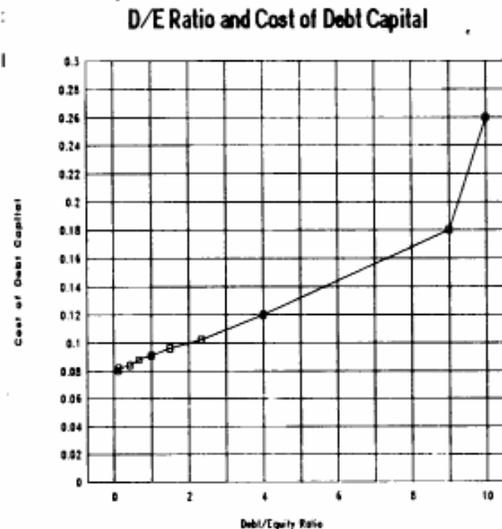
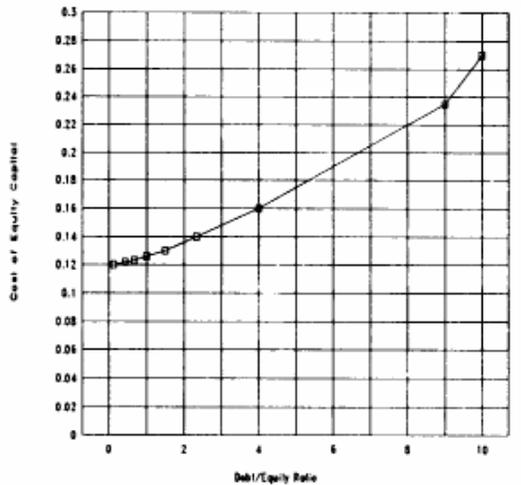


Figure 2 Illustration of Selection of Data Points for Use in Interpolation Schedules  
D/E Ratio and Cost of Equity Capital



Step 2 Compute Net operating income and Net income

(1) Compute NOI

The finance algorithm proposed and developed here requires that net operating income, commonly called EBIT (earnings before interest and taxes) have been calculated. For illustrative purposes, assume that NOI can be computed:

$$NOI = P(Q) - V(Q) - F \quad (1)$$

P price  
Q units sold  
V variable cost/expense rate  
F fixed expenses

Given the availability of NOI, then net income after taxes may be computed. This requires the computation of interest and taxes as explained in the next two steps.

(2) Compute interest expense:

Interest expense is the sum of interest on old and new debt. In order to compute interest expense it is first necessary to determine the appropriate interest rates on debt. Since the interest rate of new

debt is a function of the debt/equity ratio, this ratio must be computed:

$$DER = TD/TE \quad (2)$$

TD - Total interest bearing debt  
TE - Total equity  
DER - Debt/equity ratio

The cost of debt capital has been previously defined by the cost of capital schedules presented in step 1. Given the computation of the debt/equity ratio, the appropriate interest rate of new debt may be found by interpolation.

Interest expense now may be computed as follows:

$$IE = ORD(OD) + CRD(ND) \quad (3)$$

IE - interest expense  
ORD - old interest rate  
OD - old debt  
CRD - current interest rate  
ND - new debt

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### (3) Compute Net Income After Taxes and Interest

Financial theorists generally agree that in absence of income taxes the debt/equity ratio has no effect on the weighted average cost of capital. Therefore, the composition of the debt equity ratio is irrelevant to the determination of firm value. However, given the existence of a tax rate on business income, it can be shown that a minimum value for weighted cost of cost of capital exists over the range of possible debt/equity ratios. In other words, because of income taxes an optimal capital structure exists. Therefore, a modern finance algorithm must calculate net income per share after taxes. This may be done as follows:

$$\frac{NIAT}{T} = \frac{(NOI - IE)(I-T)}{\text{Tax rate}} \quad (4)$$

NIAT - Net in come after tax  
T Tax rate

### Step 3 Compute Current and Future Net Income Per Share

It is generally accepted that the current price per share of stock is directly affected by stockholders' evaluation of a company's growth rate. Consequently, a realistic finance algorithm must allow in some way for growth. The proposed algorithm allows for growth to be one of the determinants of market value per share.

#### (1) Compute current net income per share

The calculation of net income per share (after taxes) is a very simple calculation:

$$NIPS = N/A \text{ TINS} \quad (5)$$

NS - number of shares of stock

#### (2) Compute The Future Value of Net Income Per Share

Financial theorists generally agree that stockholders take into account the growth rate of earnings and that the market value per share represents the present value of future earnings. In order to compute future value of net income per share, some measure of the growth rate must be derived. One approach is as follows:

To establish a bench mark for growth let:

$$BNIPS = (NIPS_{t-3} + N/PS_{t-2} + NIPS_{t-1})/3 \quad (6)$$

BNIPS - Bench mark net income per share.

where BINPS represents the average net income per share. In this instance, an average over three years has been arbitrarily chosen. A basis for finding a compound growth rate can be found by establishing the following relationship:

$$\frac{PVNIPS}{(1 + GR)^{PP}} = NIPS \quad (7)$$

PVNIPS - present value of prior periods net income per share PP - number of past periods

This equation allows the present value of the current net income per share to be computed at various discount rate. The growth rate (GR) has been found when  $BNIPS = PVNIPS$ . The procedure for finding the growth rate is an trial an error procedure. The value of PP is a parameter selected by the simulation administrator. How the

growth rate may in computed in a computer program may be seen by observing lines 600-800 of program presented in the appendix.

The growth rate is found by the a process similar to that used to compute the internal rate of return of an investment project. This procedure requires that the net income per share for a specified number of past periods be averaged. The use of an average as a bench mark in computing the growth rate reduces or smooths large abrupt changes in market value due to a large increase or decrease in earnings for just one period.

Given the growth rate, net income per share at some defined future period must be estimated. This increment in net income may be computed as follows:

$$NIPSF = N/PS (1 + GR)^{FP} \quad (8)$$

NIPSF - Future value of increase in net income  
Per share  
FP - Number of future periods

This equation requires that the number of future periods that the stockholders are willing to extend growth be specified. The value of FP, future periods, is a parameter determined by the simulation administrator.

Only the increment in future net income per share requires discounting for the three year period. Therefore, incremental future income may be computed as follows:

$$INIPS = NIPSF - N/PS \quad (9)$$

INIPS - Incremental net income per share

The increment is calculated simply by subtracting current net income per share from the projected future net income per share.

#### (3) Determine the Cost of Equity Capital

The cost of equity capital has been previously defined by the cost of capital schedules presented above. Given the debt/equity ratio previously calculated, the cost of capital may be found by interpolation.

Assume debt to be \$1,000 and equity \$2,000. Given that the debit/equity ratio is .333, then by interpolation the cost of capital would be .1267.

#### (4) Compute the Discounted Value of Future Net Income Per Share.

Increases in market value are caused by increases in earnings per share. The proposed model assumes that stockholders will compute the future value of net income per share as illustrated in equation 8. The model then discounts the incremental future net income as computed in equation 9 by using the cost of equity capital computed in step 3. The discounted value of future earnings per share may be computed:

$$DIN/PS = INIPS / (1 + ECC)^{FP} \quad (10)$$

INIPS - Incremental net income per share  
ECC - Cost of equity capital  
FP - Future periods  
DINIPS - Discounted incremental net income per share

### Step 4 Compute Market Value Per Share

In this step, the present value of one share of stock is the net income per share last period plus the discounted value of the future

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income per share last period plus the discounted value of the future value of the increase in net income per share. Market value per share now may be simply computed as:

$$MVPS = (N/PS + DIN/PS) / ECC \quad (11)$$

### Evaluation and Illustration of Algorithm

The algorithm is now complete. The primary objective, market value per share, is computed in equation (11). The algorithm basically correspond to current theory. It is flexible and allows different theories to be implemented by simply changing parameters and redrawing the relationships of the cost of debt and equity capital to the debt/equity.

A computer version of the algorithm is shown in the Appendix. Implementation of this algorithm in any simulation should require very little time. The strength of this algorithm is that it is flexible and allows different functional relationships between the debt/equity ratio and cost of capital to be created. The model is indifferent as to whether cost of capital relationships are linear or curvilinear. Also, an extremely important aspect of the model is the feature that takes into account the growth rate of net income.

One important finance variable not explicitly included in the above model is dividend payout rate. The model presented above corresponds to that branch of theory, which argues that the dividend payout has no effect on cost of capital and consequently the market value per share of stock. Implicit in the above model is the assumption that the payment of dividends would reduce the growth rate.

### Example of Finance Algorithm Output

The proposed algorithm has been thoroughly tested with numerous combination of finance decisions. As a result of this testing some refinements were made. An example of output from the proposed algorithm is shown in figure 3. Test data and assumed functions on which the example is based is also shown. The example in figure 3 shows that based on the test data, market value per share would be \$107. The financial decisions and conditions that contributed to the market value per share were: (1) a debt equity ratio of 1 and (2) a growth rate of 14.6%. Given the debt/equity ratio functions for debt capital and equity capital, the algorithm determined that the appropriate cost of capital for debt and equity were respectively 9.6% and 12.6.

### SUMMARY

Even though a general management or business enterprise type of simulation does not require many financial decisions, it is critically important that a good finance algorithm be operational within the computer model. Per share market values that are too high or too low can result can significantly distort cash flows from issue of stock. Also improper per share values can result in incorrect evaluation of student performance.

The algorithm presented here is comprehensive in that all of the important variables recognized in financial literature are included. Two market value per share variables, the debt/equity ratio and the growth rate of net income, have been successfully integrated into matrix of variables that determine market value per share. Because the game administrator can change the slopes of the cost of capital functions and also change parameters, different theories of finance can be simulated.

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Figure 3  
Illustration of Output from the Proposed Finance Algorithm

Test data:											
Balance Sheet:						Income statement					
Current asset						Price				\$10	
Long term debt (TD)						Variable cost rate (V)				\$3	
Stockholder's equity (TE)						Fixed expenses (F)				\$5,000	
No. of shares (NS)						Quantity (Q)				1,000	
Future periods (FP)						Net Income last period (NIPS <sub>T-1</sub> )				\$812.50	
Debt Equity factors array (DEPF)						Net Income 2 period ago (NIPS <sub>T-2</sub> )				\$677.00	
0	.111	.25	.43	.67	1.0	1.5	2.333	9	100	\$564.00	
Cost of equity capital array											
.12	.1210	.1220	.1230	.1260	.1300	.1400	.1600	.2350	2700		
Cost of debt capital array											
.0800	.0820	.0880	.0840	.0910	.0960	.1020	.1200	.1800	.2600		
Balance Sheet December 31, 1993						Income Statement Year end 1994					
Assets \$6,000						Sales					\$10,000
Current	0					Variable expenses					3,000
Fixed	0					Contribution margin					7,000
Other assets											
Liabilities											
Current liability	0					Fixed expense					5,000
Long term debt	\$3,000					Net operating income					2,000
Stockholder's equity						Interest					288
Common stock (100 shares)	\$3,000					Taxes					685
Retained earnings						Net income					\$1,027
Cost of equity capital (ECC)						Market value per share (MVPS)					\$106.67
.126						Net income per share (NIPS)					\$10.27
Cost of debt capital (CRD)						Discounted incr. Income (DINIPS)					\$3.59
.096											
Growth rate (GR)											
.146											
Future net income per share (NIPSF)											\$15,459

## Appendix

### Computerized Finance Algorithm for Computing Market Value Per Share

110 CLS

120 DEPF(1) = 0: DEPF(2): DEPF(3) = .25: DEPF(4) = .43: DEPF(5) = .67: DEPF(6) = 1!: DEPF(7) = 1.5: DEPF(8) = 2.3333:  
DEPF(9) = 4!: DEPF(10) = 9

130 BR(1) = .08: BR(2) = .082: BR(3) = .084: BR(4) = .088: BR(5) = .091: BR(6) = .095: BR(7) = .102: BR(8) = .12: BR(9) = .18:  
BR(10) = .26

140 KE(1) = .12: KE(2) = .121: KE(3) = .122: E(4) = .123: KE(5) = .126: KE(6) = .133: KE(7) = .14: KE(8) = .16: KE(9) = .235: KE(10)

150 P = 10: Q = 1000: F = 5000: V = 3: SKIP = 0

160 ORD = .096: OD = 0: ND = 3000: TE = 3000

170 NS = 100: T = .4: ND = 3000: CRD = .1: PD = 4

180 NI(1) = 564: NI(2) = 677: NI(3) = 812.5

190 NSCS(1) = 100: NSCS(2) = 100

200 REM computation of Net operating income

210 NOI = (P \* Q - V \* Q) - F

220 REM Determination of new debt interest rate

230 DER = TD / TE

240 VALUE = DER: FOR I = 1 TO 10: ARRAY1(I) = DEPF(I): NEXT: FOR I = 1 TO 10: ARRAY2(I) = BR(I): NEXT: GOSUB 2000

250 CRD = FRACT

300 REM Computation of interest expense

310 IE = (ORD \* OD) + (CRD \* ND)

400 REM computation of net income after tax

410 NIAT = (NOI - IE) (1 - T)

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420 NI(PD) = NIAT  
430 NSCS(PD) = NS

500 REM Computation of net income per share  
510 NIPS = NIAT/NS

600 REM computation of Growth Rate  
610 R=.001  
620 BNIPS = ((NI(PD - 3) + NI(PD - 2) + NI(PD - 1)) / 3) / NS  
650 PV = NIPS / (1 + R) PP  
640 R = R + .001  
670 IF PV > BNIPS THEN GOTO 620  
680 GR = R

700 REM Computation of future value of Net income per share  
712 IF SKIP = 1 GOTO 800  
715 IF GR < .01 THEN GOTO 750  
730 NIPSF = NIPS \* (1 + GR) FP  
  
735 NIPS = NIPSF - NIPS  
740 GOTO 800  
750 NIPS = 0

800 REM determine the cost of equity capital  
810 VALUE = DER: FOR I = 1 TO 10: ARRAY1(I) = DEPF(I): NEXT: FOR I = 1 TO 10: ARRAY2(I) = KE(I): NEXT: GOSUB 2000  
820 ecc = FRACT

900 REM Compute the Discounted value of future net income per share  
910 DINIPS = INIPS / ((1 + ecc) FP)

1000 REM Compute market value per share  
1010 MVPS = (NIPS + DINIPS) / ecc  
1100 PRINT "NOI "; NOI  
1110 PRINT "ECC "; ecc  
1115 PRINT "CRD "; CRD  
1120 PRINT "IE "; IE  
1130 PRINT "NIAT "; NIAT  
1140 PRINT "NIPS "; NIPS  
1142 PRINT "INIPS "; INIPS  
1150 PRINT "GR "; GR  
1160 PRINT "NIPSF "; NIPSF  
1170 PRINT "DINIPS "; DINIPS  
1180 PRINT "MVPS "; MVPS  
1 200 INPUT "press enter to continue?"; XX

2000 REM Interpolation algorithm  
2902 FOR I = 1 TO 10  
2920 IF VALUE < ARRAY1(I) THEN GOTO 2950  
2930 IF VALUE >= ARRAY1(I) AND VALUE <= ARRAY1(I + 1) THEN TV = I ELSE GOTO 2970  
2940 GOTO 2980  
2950 TV = I  
2960 GOTO 2980  
2970 NEXT I  
2980 LL = ARRAY1(TV)  
2990 HL = ARRAY1(TV + 1)  
3000 LR = ARRAY2(TV)  
3010 HR = ARRAY2(TV + 1)  
3020 FRACT = (((VALUE - LL) / (HL - LL)) \* (HR - LR)) + LR  
3030 RETURN