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Probabilistic Profit Planning: A Feasible Approach

Richard J. Tersine

Cyrus A. Altimus Jr.

The recent SEC announcement that corporate estimates of future earnings could be publicly announced strongly implies that the next step could be that they are required to be. This will lead to a much more rigidly determined earnings forecast —

PROBABILISTIC PROFIT PLANNING: A FEASIBLE APPROACH

by Richard J. Tersine
and Cyrus A. Altimus, Jr.
Old Dominion University

Corporations have always been interested in profit planning. The usual approach has been through deterministic budgets by both formal and informal processes. Profit-planning information is vital for internal decision making. Decisions concerning the selection, procurement, and utilization of resources are highly dependent on the accuracy of profit projections. Profit planning in the form of released estimates of future performance to financial institutions has an important impact on the stock market vis-a-vis security prices.

A future requirement?

Historically, corporations have revealed future economic performance informally with less than full public disclosure. This situation has dismayed many regulatory agencies. The Securities and Exchange Commission now permits and may someday require corporations to publish forecasts of their earnings.[1] Proponents argue that simple fairness, not to mention legal requirements, dictates that forecasts be made public. Opponents argue that forecasts could result in a flood of lawsuits against management for any lossses.

As long as profit planning was only for internal management use, there was no necessicy for formal control procedures. A requirement for public disclosure mandates the need for common formal procedures. .Although full disclosure of profit forecasts is not required at this time, it may not be very far off on the time horizon. This article will develop a probabilistic profit model that the authors believe could meet this impending future need.

The typical profit budget for a single-product company is shown in Exhibit 1, page 47. This direct-costing format permits the use of breakeven and cost-volume-profit analysis. Fixed costs have been segmented into managed and committed costs. Managed fixed costs are costs that can be modified in the short run, while committed fixed costs are both useful and appropriate in the preparation of probabilistic budgets.

The segmentation of fixed costs into managed and committed costs allows a more detailed examination of the figures used to develop the profit budget. However, the budget in Exhibit 1 and others like it allow for no indication of potential variability of the various estimates. The specific items in the budget are subjective estimates of the most likely values to occur. The neglect of variability is the most outstanding weakness in the typical deterministic profit budget. The uncertainties and dynamic fea-

1—Securities Act Release 5362 and Exchange Act Release 9984, February 2, 1973, "Statement by the Commission on Disclosure of Projections of Future Economic Performance."

tures surrounding an organization create a difficult atmosphere for the single most likely estimates used for profit planning. Precise definitions of such potentially volatile variables as revenue, selling price, sales mix, labor cost, and material cost are difficult—if even possible. When single estimates, rather than a range of possible outcomes, are used, the significance of dispersion is ignored.

Budgets can be considered plans for the future which incorporate forecasted performance levels. Since the future is uncertain, nobody can forecast the future perfectly. A useful approach is to treat uncertainty in terms of risk. Risk requires the gathering of additional information, insights, judgments, experience, hunches, and intuition to be able to make some kind of probability estimate about the relative likelihoods of performance levels. Futuristic probability estimates frequently require both objective and subjective probabilities. Probabilities are objective if nearly everybody would arrive at the same values. Probabilities are subjective if they are determined by judgment, intuition, and experience.

With subjective probabilities, not all decision makers from different backgrounds would establish the same probability distribution for events. While this fact can be discouraging, there are benefits from such a process of subjective assimilation. It permits an analysis of one-of-a-kind problems that managers previously had to handle without assistance. It encourages meaningful communication among members of the organization by providing a common language in which to discuss problems. Explicit consideration of performance risk sharpens thinking because it makes disagreements between managers explicit and puts the importance of various factors into perspective. The preparation of the model could be the greatest benefit from risk analysis.

While a stochastic approach to profit planning may be advantageous, the difficult task is to model realistic performance in a probabilistic framework. The accounting profession has not specified how stochastic profit budgets should be constructed. As early as 1966, the American Accounting Association encouraged the adoption of probabilistic financial statements, but did not offer any guidelines.[2] Numerous authors have addressed the problems of risk and uncertainty.

EXHIBIT I

Profit Budget for the Year Ending 197X

Sales	100,000 units @ $5		$500,000
Variable Costs			
Manufacturing	$2 per unit	$200,000	
Marketing	$1 per unit	100,000	300,000
Marginal Contribution			$200,000
Managed Fixed Costs			
Manufacturing		$ 10,000	
Marketing		5,000	
Administration		20,000	35,000
Short-Run Margin			$165,000
Committed Fixed Costs			
Manufacturing		$ 80,000	
Marketing		15,000	
Administration		20,000	115,000
Net Income Before Taxes			$ 50,000
Taxes—50%			25,000
Net Income After Taxes			$ 25,000

Variety of approaches

Jaedicke and Robichek[3] used the normal probability distribution to consider risk in cost-volume-profit analysis. Magee[4] developed decision trees to determine expected net present value of alternative investments. Hertz[5] applied computer simulation with specified distributions to obtain the expected return on investment. Hillier[6] incorporated risk into capital investment decisions by assuming a normal distribution. Byrne et al.[7] recommended decision trees and network concepts in financial statements. Tersine and Rudko[8] advocated bivariate risk treatment in capital investments with uncertain lifetimes. Coughlan[9], Hespos and Strassman[10], and Springer et al.[11], provided procedures for developing stochastic financial statements. Greer[12] developed procedures for

2—American Accounting Association, *A Statement of Basic Accounting Theory*, 1966, pp. 38, 59, and 65.

3—Jaedicke, R. K., and A. A. Robichek, "Cost-Volume-Profit Analysis Under Conditions of Uncertainty," *The Accounting Review*, October, 1964, pp. 914-26.

4—Magee, John F., "How to Use Decision Trees in Capital Investments," *Harvard Business Review*, September-October, 1964, pp. 79-96.

5—Hertz, David B., "Risk Analysis in Capital Investment," *Harvard Business Review*, January-February, 1964, pp. 95-106, and "Investment Policies that Pay Off," *Harvard Business Review*, January-February, 1968, pp. 96-108.

6—Hillier, Frederick S., "The Derivation of Probabilistic Information for the Evaluation of Risky Investments," *Management Science*, Volume 9, 1963, pp. 443-57.

7—Byrne, R., et al., "Some New Approaches to Risk," *The Accounting Review*, January, 1968, p. 33.

8—Tersine, Richard J., and William Rudko, "A Bivariate Stochastic Approach to Capital Investment Decisions," *The Engineering Economist*, May, 1972, pp. 157-76.

9—Coughlan, John W., "Profit and Probability," *Advanced Management Journal*, April, 1968.

10—Hespos, R. F., and P. A. Strassman, "Stochastic Decision Trees for Analysis of Investment Decisions," *Management Science*, August, 1965, pp. 244-59.

11—Springer, Clifford H., et al., *Probabilistic Models*, Irwin, 1968, chapts. 4 & 5.

12—Greer, Willis R., "Capital Budgeting Analysis with the Timing of Events Uncertain," *Accounting Review*, January, 1970, pp. 103-114.

EXHIBIT 2

	Pessimistic	Most Likely	Optimistic
Sales ($5 per unit)	$400,000	$500,000	$585,000
Variable Cost			
Manufacturing	150,000	200,000	240,000
Marketing ($1 per unit)	80,000	100,000	125,000
Marginal Contribution	$170,000	$200,000	$220,000
Managed Fixed Cost			
Manufacturing	$ 5,000	$ 10,000	$ 15,000
Marketing	4,000	5,000	8,000
Administration	15,000	20,000	22,000
Short-Run Margin	$146,000	$165,000	$175,000
Committed Fixed Costs			
Manufacturing	$ 80,000	$ 80,000	$ 80,000
Marketing	15,000	15,000	15,000
Administration	20,000	20,000	20,000
Net Income Before Taxes	$ 31,000	$ 50,000	$ 60,000
Taxes—50%	15,500	25,000	30,000
Net Income After Taxes	$ 15,500	$ 25,000	$ 30,000

handling investments with uncertain lifetimes. Furst and Markland[13] applied probabilistic techniques to franchising opportunities. Many authors have described detailed approaches to probabilistic financial analysis.

Methodology

The beta distribution is a general distribution which can acquire a wide variety of shapes between any two finite values an analyst cares to choose. The beta distribution can be made symmetrical, skewed, peaked, or flat which adds the variety that describes many environmental phenomena. This flexibility of form renders the beta a useful distribution when no theoretical justification for another distribution can be found. The beta distribution currently in use in PERT fits the requirements for probabilistic profit planning. Because of its current use in planning, management should be familiar with its uses and the requirements of the needed information.

The beta asks for three estimates, i.e., a pessimistic, most likely, and an optimistic, revealing the discrete nature of the inputs. The criteria for selecting the inputs are well outlined in most texts concerning PERT. They include the statement that the pessimistic and optimistic estimate have at most a one per cent chance of being outside their stipulations barring any extreme "act of God."[14]

Three-level budget

A three-level profit budget is shown in Exhibit 2, above. The three levels are the pessimistic, most likely, and optimistic estimate respectively. As can be seen, the three-level estimates (Exhibit 2) are more informative than the most likely values (Exhibit 1). Exhibit 2 estimates show that profit after taxes can be as low as $15,500 or as high as $30,000. The use of the most likely estimate of $25,000 can, therefore, be misleading.

A range of possible profit is more meaningful than a point estimate, but it is still not adequate. A decision maker needs to know the probabilities associated with different profit levels. The beta distribution is a very efficient distribution that permits a user to obtain a tremendous amount of information from only three inputs. Ferrara and Hayya[15] advocated the beta distribution for profit planning, but they did not develop the technique to its fullest potential. They simply reverted to the assumptions of normality.

Fortunately, it is not necessary to work directly with the formulation of the beta distribution. Standard charts have been developed which allow a quick and easy solution. The first step is to standardize the mode or the value of the variable at which the frequency is at a maximum. The most likely estimate for the beta distribution is defined as the mode. The mode is standardized by the following formula:

$$r = \frac{m-p}{o-p} = \text{standardized mode}$$

where m is the mode or most likely estimate, p is the pessimistic estimate, and o is the optimistic estimate.

13—Furst, Richard, and E. Markland, "Franchising Opportunities: A Probabilistic Approach," *Financial Executive*, February, 1970, pp. 20-25.

14—Hough, Louis, *Modern Research for Administrative Decisions*, Prentice Hall Inc., 1970, p. 361.

15—Ferrara, William L., and Jack C. Hayya, "Toward Probabilistic Profit Budgets," *Management Accounting*, October, 1970, pp. 23-28.

RICHARD J. TERSINE is associate professor of business management at Old Dominion University, Norfolk, Va. He has held positions in management and engineering with several aerospace firms, including the Boeing Company, Pan American World Airways, Inc., and the Martin Company. Dr. Tersine received his D.B.A. from Florida State University, Tallahassee. He is the author of many technical articles and has coauthored **Models and Problems in Operations Management,** Grid Inc., Columbus, Ohio, 1974, with Dr. Altimus.

CYRUS A. ALTIMUS, Jr., is associate professor of business management at Old Dominion University. He was an instructor of management at the Pennsylvania State University, where he received his Ph.D. in business administration. Among his consulting engagements, Dr. Altimus has served as an education adviser to the Xerox Corporation and has researched shoplifting in the Tidewater, Va., area for the Tidewater Retail Merchants Association.

The next step is to substitute any given profit level t for which you want to determine the probability of earning less than this amount into the formula:

$$X_t = \frac{t-p}{o-p} = \text{standardized profit level for } t$$

The standardizing formulas are necessary so that Chart 1, below, can be used in establishing profit level probabilities.

By using Chart 1, the probability of earning less than a given amount can be determined.[16] Chart 1 is used in the following manner. Calculate the standardized mode (r) for the investment and the desired value(s) of X_t. Enter Chart 1 at r on the vertical axis and consult the scale at the top of the Chart to locate the curve that represents X_t. From the intersection of r and X_t, drop to the bottom scale of the chart to obtain the percentage value. The percentage value indicates the probability that the investment will earn less than the given amount X_t.

Example 1: From the information in Exhibit 2, what is the probability of earning less than $25,000?

$$r = \frac{m-p}{o-p} = \frac{25{,}000-15{,}500}{30{,}000-15{,}500} = .65$$

$$x_t = \frac{t-p}{o-p} = \frac{20{,}000-15{,}500}{30{,}000-15{,}500} = .31$$

Note that r is greater than .5, so we enter Chart 1 with the complements of r and X_t (.35 and .69). The resultant probability read from the bottom of Chart 1 is approximately .95. Since we used the complements, the probability that profit will be less than $20,000 is .05. The probability that profit will exceed $20,000 is .95.

By defining the confidence level as the probability that profit will exceed a given size, we can obtain the probabilistic information shown in Exhibit 3, page 50, about the data in Exhibit 2.

The profit level (t) for a given confidence level in Exhibit 3 is determined in the following manner. The first step is to determine X_t from Chart 1. The X_t value is obtained by finding the intersection of the standardized mode (r) and the given confidence level on the lower horizontal axis and proceeding up the curve lines to the approximate X_t value on the top horizontal scale. The profit level (t)

16—Chart 1 was taken from Willis R. Greer, Jr., "Capital Budgeting Analysis with the Timing of Events Uncertain," *Accounting Review*, January, 1970, p. 112. The chart is developed for values of the standardized mode r up to .5. For values of r in excess of .5 (r > .5), it is necessary to work with the complements of both r and X_t. The probability read from the chart represents the probability that the investment will earn more than t.

CHART 1

BETA CURVE AREA CHART

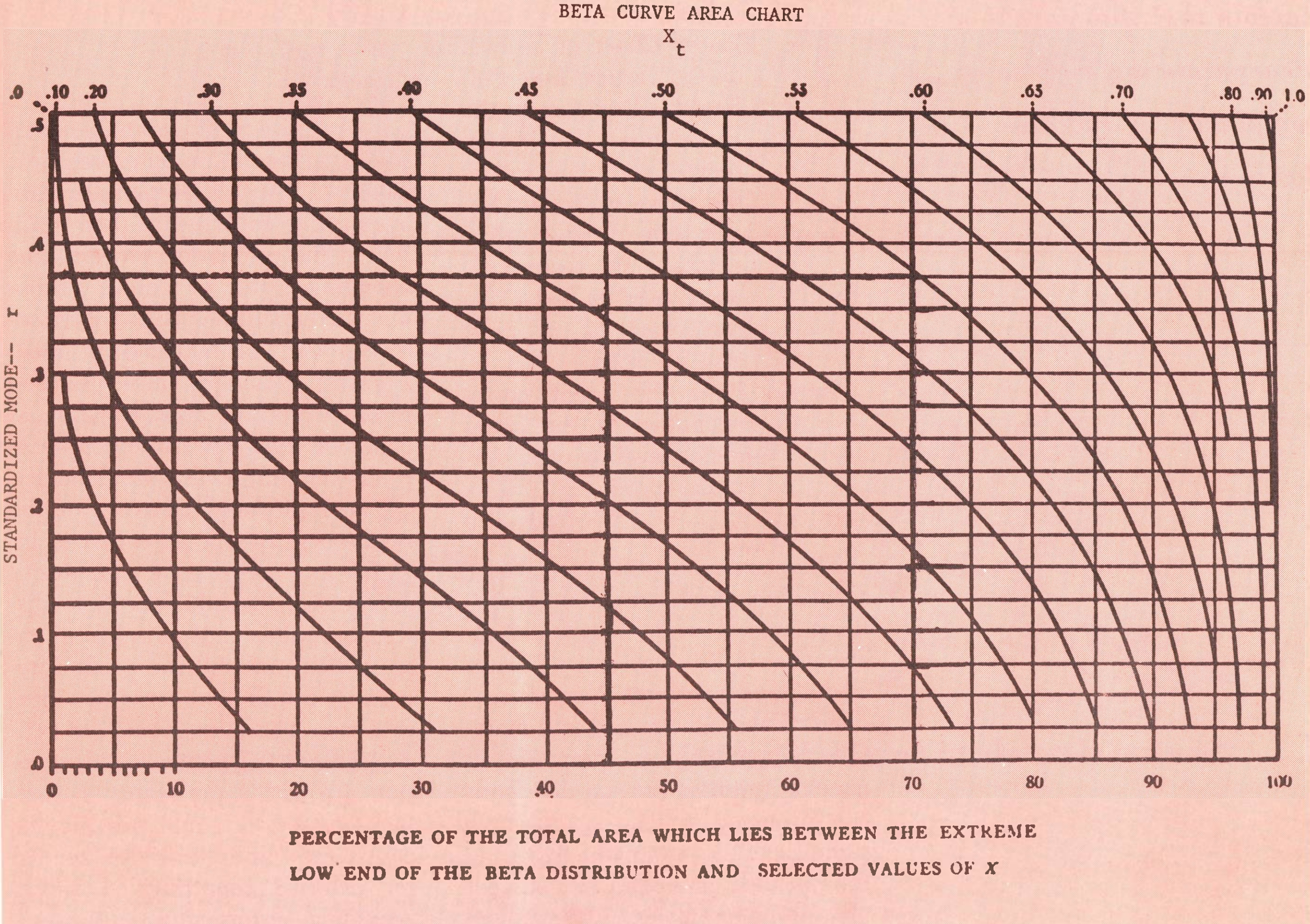

EXHIBIT 3

Confidence Level	x_T	Formula*		Profit(T)
95%	.31	.31(30,000 − 15,500) + 15,500	=	$20,000
75%	.49	.49(30,000 − 15,500) + 15,500	=	22,600
50%	.62	.62(30,000 − 15,500) + 15,500	=	24,490
25%	.73	.73(30,000 − 15,500) + 15,500	=	26,085
15%	.79	.79(30,000 − 15,500) + 15,500	=	26,955

*Profit $= t = x_t(o - p) + p$

is then obtained from the following formula:

$$t = X_t\,(o\text{-}p) + p$$

Steps in the procedure

The following is a recap of the steps in the procedure:

Step 1. Determine the optimistic (o), most likely (m), and pessimistic (p) budgets.

Step 2. Standardize the mode (r) use formula $r = \frac{m - p}{o - p}$ (Note: if r greater than .50 use reciprocal)

Step 3. Determine x_t value(s) corresponding to the confidence levels required. Enter Chart at r level on the vertical line. Follow this line over to the confidence level required and then follow the curve up to the top axis to read the x_t value. (Note: if reciprocals were used to find r, the reciprocal of x_t must also be used.)

Step 4. Find the profit corresponding to the confidence level by using formula: profit $= t = x\,(o - p) + p$

There are many situations where a business might require a minimum level of profit. This could occur when a firm has had a history of dividend payments that management feels constrained to maintain but existing or proposed financing requires that no dividends be disbursed unless a minimum profit level is attained. By using the outlined procedure a manager can find the probability of generating some desired level of profit.

Example 2: From the information in Exhibit 2, what is the probability of earning at least $23,000 profit?

$$\text{Profit} = t = x_t\,(o - p) + p$$
$$23{,}000 = x_t\,(30{,}000 - 15{,}500) + 15{,}500$$
$$x_t = .52$$

The probability can now be read from Chart 1 by entering at the .48 level on the top scale and following the curve down to the intersection with the standardized mode (.35). The probability is then read from the bottom of the chart. In this case, there is a .71 probability that the firm will earn at least $23,000.

Probability profit planning requires an estimate based largely on guesswork. But the beta distribution, familiar from PERT, does provide a flexible tool that can incorporate any degree of complexity or realism desired . . .

Conclusion

Probability profit planning necessitates a stochastic interpretation. The beta distribution permits management to incorporate their abilities in the estimation process. The changing states of nature (economy, competition, legal environment) can be reflected in management estimates and revealed through the beta approximation. It could be integrated into corporate profit planning with little difficulty.

The basic characteristics of the beta model can be extended to include any degree of complexity and realism desired. The beta distribution does not provide a panacea for probabilistic profit forecasting, but it does provide a flexible tool. The data inputs are very simple and the tri-level budget inputs are within the realm of existing practice. It could provide the consistency and flexibility needed for external reporting on future economic performance.