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Application of Risk Analysis in Investment Decision Making for New Products

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APPLICATION OF RISK ANALYSIS IN INVESTMENT DECISION MAKING FOR NEW PRODUCTS

by

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Chul Paik

APPLICATION OF RISK ANALYSIS IN INVESTMENT
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This study presents the development of a quantitative model to deal with the decision to invest or not invest in the development and production of a new product. It is most applicable to new products which present a high probability of economic failure. The model employs only simple mathematics and statistics, so the decision maker can easily understand the model.

The model uses as input data three variables. These include: (1) the risk of product failure, (2) the maximum loss a company can afford in an investment, and (3) the estimated project cost. These three variables combined furnish as output a recommendation to invest or not invest. All operations of the model are implemented on a user-friendly computer program written in BASIC.

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CHAPTER I

INTRODUCTION

This introductory chapter presents the statement of the problem, the objective of the study, and the outline of the study.

Statement of the Problem

The investment decision making for new products based on commonly employed methods of analysis such as net present value, payback period, and internal rate of return does not provide satisfactory information to the decision maker. These methods do not consider both the uncertainties involved in forecasting outcomes and the maximum loss a company can afford in an investment. Furthermore, methods that incorporate uncertainties are often so complicated that many decision makers avoid them.

Objective of the Study

The objective of this study is to develop a simple quantitative model that deals with the decision to invest or not invest in a new product. The factors considered are: (a) incorporation of the risk of product failure, and the maximum loss a company can afford in an investment; (b) use of only simple mathematics and statistics, so the decision maker can easily understand the model and therefore use it correctly and efficiently; and (c) implementation of all operations of the model in a computer.

Outline of the Study

This study is divided in five chapters. The first chapter presents the statement of the problem and the objective of the study. Chapter two presents a review of some backgrounds. The review includes decision analysis, risk analysis, new products, and conclusions from the review. Chapter three presents all steps of the development of the model. Three examples are illustrated applying the model proposed. Chapter four describes the computer program written to execute all operations of the model. Chapter five presents conclusions from the model developed, and recommendations for further study.

Two appendices are included. They are: (a) description of Raiffa's fractile assessment procedure, the consensus method, and the Delphi technique; and (b) the computer program (flow chart, program listing, an output of the program, and the instructions to use the program).

CHAPTER II

BACKGROUND

Introduction

The objective of this chapter is to inform the reader of the necessity to develop a model that deals with the decision to invest or not invest in new products which present a high probability of economic failure. The chapter begins with a brief review of conventional decision analysis followed by a brief review of risk analysis. Then some aspects of new products launched in the market are presented. Finally, conclusions are drawn based on the review.

Decision Analysis

Most conventional methods of analysis are based on a single most likely value estimation. Examples are net present value, payback period, and internal rate of return. In the decision making process, the results obtained from any of these methods are used by the decision maker. Since the methods ignore the uncertainty, the decision maker must subjectively "guess" the risk and then make a decision. According to Maxim and Cook (1972), there are two important limitations in conventional analysis in the presence of uncertainty: (1) the analysis does not furnish the range and likelihood of possible outcomes of an investment, and (2) the analysis may not give an accurate expected outcome.

Risk Analysis

There are many definitions of risk analysis. Hertz and Thomas (1983) define risk analysis as follows:

> The term risk analysis is used here to denote methods which aim to develop a comprehensive understanding and awareness of the risk associated with a particular variable of interest (be it a payoff measure, a cash flow profile, or a macroeconomic forecast). In other words, a forecast is obtained for a variable of interest in the form of a probability distribution. (p. 1)

Kabus (1981) defines risk analysis as "A technique for quantifying the risks resulting from the uncertainties in the inputs relevant to making a choice among alternative courses of action. It does this by generating information that shows the possible outcomes to which each course of action might lead and the probability of each outcome occurring" (p. 42). Booker and Bryson (1985) simply define risk analysis as "A methodology for assigning probabilities to accidents, malfunctions, losses, or other negative aspects of a program or experiment" (p. 6). According to Maxim and Cook (1972), the approach to risk analysis in investment involves: (a) specification of a set of relations between relevant investment factors and investment outcomes, (b) determination of a probability distribution for each of the variables identified in step a, and (c) combination of the probability distributions for the input factors to measure the worth of the investment in the form of probability distribution.

In risk analysis, subjective probabilities are developed for variables that present a significant degree of uncertainty. The subjective probability is an individual's quantified intuition in estimation of an event. The subjective probability distribution can be obtained using different techniques such as Raiffa's fractile assessment procedure, the consensus method, and the Delphi technique. A description of each of these three techniques is given in appendix A.

The testing and correcting activities, that is, reevaluation after first complete estimation, are important aspects in risk analysis. To increase the reliability of the estimations calculated or assumed in quantification of input variables, some techniques are used to improve the accuracy. The most used technique is the sensitivity analysis.

New Products

New products launched in the market often fail to generate more revenue than the cost of the project. McIntyre and Statman (1982) cite a source by Booz, Allen, and Hamilton that between 60 and 90 percent of all new products end their first year as failures, and are either totally withdrawn or left unsupported. Cooper and More (1979) reported that the failure rate of new products was somewhere between 50 and 80 percent.

The risk of product failure varies from product to product. Usually, the more innovative the product is, that is, the less the similarity to existing products, the higher the risk of failure is. This can be attributed to several factors: (a) a company cannot forecast accurately sales revenues because of the difficulty in estimation of the market size and its growth rate, (b) local government may restrict the product with regulations, and (c) negative environmental or social problems can arise after the introduction of the product on the market.

An example of a new product failure due to problems that arose after its introduction on the market is illustrated by Evans (1987), "In addition to the 'normal' causes of uncertainty, firms which introduce new products may be exposed to uncertainty because of their failure to anticipate correctly the environmental and/or social impacts of the embodied technology. The experience of A. H. Robins Company is illustrative. Due to large potential lawsuits against it stemming from the health impacts of its Dalkon Shield, A. H. Robins was forced to file for protection under Chapter 11 of the U. S. Bankruptcy Code in August 1985" (p. 263). Another example comes from the case of the automobile Ford Pinto. The negative publicity of the product by public criticism concerning the design of its fuel tank, susceptible to leakage and fires upon collision, was responsible for decline in sales after several years of successful sales. From one of Ford's best selling cars, the sales decreased 63 percent in market share over a three year period (Weinberger & Romeo, 1989).

Conclusions from the Review

Conventional methods of analysis present limitations when applied to investments in presence of risk. These methods do not explore the uncertainties involved in forecasting outcomes. The incorporation of risk analysis in decision analysis helps to lessen the problem involved in investment decision making. But it is not sufficient when applied to new products which present a high probability of economic failure. In investment of new products, it is also important to consider the maximum loss a company can afford in order to avoid a delicate financial situation in case of product failure. Thus, it is recommended to develop a decision model appropriate to deal with investments in new products that includes the risk of product failure and the maximum loss a company can afford in an investment. In this study, a product is considered a failure when the difference between sales revenues and cost of the project becomes negative.

CHAPTER III

DEVELOPMENT OF THE MODEL

Introduction

This chapter presents the development of a decision model for investment in new products using risk analysis method. The development of the model is divided in two parts: (1) measurement of the Risk of Product Failure (RPF); and (2) investment decision based on three variables including: the risk of product failure, the Estimated Project Cost (EPC), and the Maximum Loss a Company can afford in an investment (MLC). The risk of product failure is measured using as input data a set of variables that contribute to product failure (e.g., negative environmental/social impact). Figure 1 shows the flow diagram for the decision model. The estimated project cost is the total estimated cost involved in the search, screening, business analysis, development, production, marketing, commercialization, and any other expenses related to the development and manufacturing of a new product. The maximum loss a company can afford in an investment is established by the company, and represents the maximum amount the company can lose without facing a delicate financial situation. The model employs only simple mathematics and statistics.

First, the method to measure the risk of product failure is presented. Then the investment decision method, based on three variables (RPF, EPC, and MLC), is presented. Finally, three examples applying the model proposed are presented.

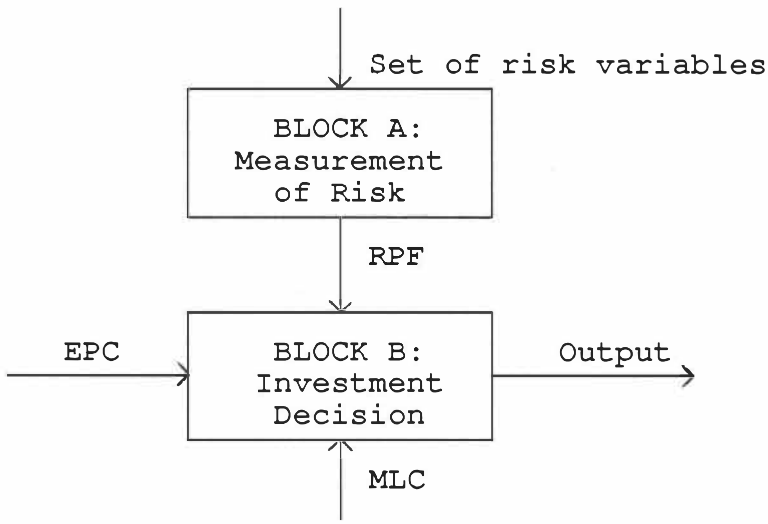


Figure 1. The Flow Diagram for the Decision Model.

Measurement of the Risk of Product Failure

The measurement of the risk of product failure requires six steps: (1) identification of variables that contribute to risk of product failure (risk variables); (2) separation of risk variables in groups so that the variables in each group are correlated; (3) assignment of relative weight (importance) to each group; (4) assignment of relative weight to each variable within a group; (5) quantification of risk variable; and (6) determination of the risk of product failure.

Risk Variables

In the first step the risk variables are identified. Let v(x), x= 1, 2, . ., n denote risk variable x from a total of n risk variables.

The risk variables can be related to internal (within the company) or external (e.g. market, government regulations, inflation, etc.) factors. They are identified from internal company data, interviews with company personnel engaged in the new product development, literature, government data, research institute data, educational institute data, routine customer visits, correspondence with manufacturers of new products, and consultants. Tables 1 and 2 list some common risk variables related to internal and external factors for any new product.

Table 1

Risk Variables Related to Internal Factors

Risk Variables
Insufficient market research
Negligible savings or other benefits that the product offers to users
Inadequate sales force allocation

Table 1--Continued

Risk Variables
Inadequate promotion and advertising strategies
Inappropriate distribution channels
Inappropriate price
Long period of project development
Utilization of fast growing technology
Ease of product duplication
Product likely to become obsolete soon
Product likely to have short life cycle
High technological sophistication and complexity

Table 2

Risk Variables Related to External Factors

Risk Variables
Negative environmental/social impact (Violation of regulations, social harms, health hazards, etc.)
Similar product competitors put on the market
Market with high fluctuation in demand
High market competitiveness
Requirement of a major change in attitude or behavior of the user of product

Table 2--Continued

Risk Variables
Potential unacceptance of the product by different kinds of markets (e.g., regions, ages, sexes, etc.)

The risk variables depend on the nature of the product, and each product will have its own list. Note that the description of each risk variable is phrased in a special manner. If the risk variable is true (i.e., if there is insufficient market research) then the probability that the product will fail is increased. If it is not true, then the probability of failure is decreased.

Separation of Risk Variables in Groups

In this step the variables identified in the previous step are separated in groups, so that each group contains those risk variables which are correlated. Thus, variables not in the group can be assumed to be independent. The v(x), x= 1, 2, . ., n from the previous section are rearranged in this step in the following way:

$$V(i,j) = v(x), \quad i = 1, 2, \ldots, k \quad j = 1, 2, \ldots, m(i)$$

$$\sum_{i=1}^{k} m(i) = n$$

In this notation i is the index for the group number, j is the index for the set of variables in group i, k is the number of groups, and m(i) is the number of variables in group i.

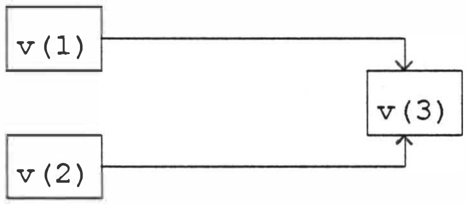
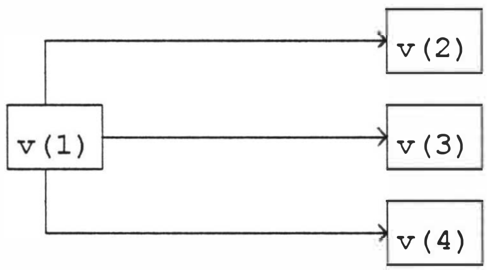
If a risk variable acts independently from an other variable, then the behavior of the variable does not affect the behavior of the other variable. But if two variables are correlated, then the behavior of one variable may affect the behavior of the other variable. For example, the risk variable "Inappropriate distribution channels" will not affect the variable "Negative environmental/social impact." In this case, the two variables are independent. On the other hand, the risk variable "Ease of product duplication" may influence the risk variable "High market competitiveness." In this case, the two variables may be correlated. Table 3 gives three examples of common types of correlations.

Type 1 shows the case where v(1) influences v(2). For example, let v(1) = "Long period of project development," and v(2) = "Similar product competitors put on the market." Usually, a long period of project development may allow competitors to put a similar product on the market.

Type 2 is the case where v(3) is influenced by both v(1) and v(2). Consider v(1) = "Utilization of fast growing technology," v(2) = "Product likely to become obsolete soon," and v(3) = "Product likely to have short life cycle." The use of fast growing technology and a

Table 3

Diagrams of Some Types of Correlations

Types of Correlations	
I. Type 1:	
II. Type 2:	
III. Type 3:	

product that is likely to become obsolete soon may lead to a short product life cycle. In this type of correlation a problem can arise if v(1) and v(2) are independent, therefore they should not be in the same group, but both lead to v(3). In this situation, the problem is analyzed considering all possible combinations of the variables: (a) v(1) and v(3) in one group, and v(2) in other; (b) v(2) and v(3) in one group, and v(1) in other; (c) v(1), v(2), and v(3) each in different groups; or (d) v(1), v(2), and v(3) all in one group. If the correlation between v(1) and v(3) is stronger than the correlation between v(2) and v(3), then the alternative (a) may be the best choice. Now, suppose that the correlation between v(1) and v(3), and v(2) and v(3) both have almost the same strength. Moreover, v(3) is of major importance, and v(1) and v(2) are not. Then the alternatives (d) and (c), in that order, may be the best choices. If v(1), v(2), and v(3) are all major variables with about the same importance, then alternative (a), (b), or (c) is suggested depending on the following situations: if the correlation between v(2) and v(3) is stronger than between v(1) and v(3), then the alternative (b) is suggested. On the other hand, alternative (c) may be suggested if the correlation between v(1) and v(3), and between v(2) and v(3) both seem to have almost the same strength. In further steps these variables will be weighted according to relative importance. The more important the variable the larger the relative weight.

Type 3 is the situation where the outcome of variable v(1) affects the variables v(2), v(3), and v(4). Suppose v(1) = "Ease of duplication," v(2) = "Inappropriate price," v(3) = "Product likely to have short life cycle," and v(4) = "High market competitiveness." Ease of duplication may cause a product to have an inappropriate price, short life cycle, and high market competitiveness due to duplications by competitors. In this type of correlation a problem can arise when v(2), v(3), and v(4) are independent of each other. In this situation the problem is analyzed in the same way as proposed for type 2.

Weighing Assignment to Groups

In this step weights are assigned to each group according to relative importance. Each weight is non-negative and the sum of all weights is 1. That is,

G(i) = the relative weight of group i
(i = 1, 2, . ., k)

$$\sum_{i=1}^{k} G(i) = 1, \quad G(i) \geq 0$$

The weighing process starts with the listing (ranking) of groups in order of relative importance in contribution to risk of product failure. The more a group contributes to risk of failure, the higher is the ranking of the group. The relative weights are assigned to the ranked groups, from the first to last, in decreasing weights. The consensus method or the Delphi technique may be useful when assigning weights.

Weighing Assignment to Each Variable in a Group

In this step each variable of a group is assigned a weight according to its relative importance within the group. Each weight is non-negative and the sum of the weights within the group is 1. That is, W(i,j) = the weight assigned to the variable j of group i. (V(i,j), i= 1, ..,k, j= 1, ..,m(i))

and, for each i

$$\sum_{j=1}^{m(i)} W(i,j) = 1, \quad W(i,j) \geq 0$$

The weighing process starts with the listing of the variables of a group in order of relative importance of contribution to risk of product failure. The more a variable contributes to risk of failure, the higher the ranking of the variable. The relative weights are assigned to the ranked variables, from the first to last, in decreasing weights. The consensus method or the Delphi technique may be useful when assigning weights to each variable of a group.

Quantification of Risk Variable

To quantify each risk variable, a scale of 0 to 100 is used. In this scale, 0 corresponds to the value that in the judgement of the estimator the event of the risk variable will not significantly contribute to economic failure. On the other hand, 100 corresponds to the value that in the judgement of the estimator the event of the risk variable will significantly contribute to economic failure. The number 50 in the scale is considered as a neutral value. Let

Q(i,j) = the quantified value of the risk variable V(i,j) in the scale.

The Q(i,j) is the value based on the scale of 0 to 100 that in the judgement of the estimator it is the most likely value to represent the risk variable. This value divides the interval from 0 to 100 into two judgementally equally likely parts. That is, for the estimator it is indifferent to chose the interval between 0 and Q(i,j), or Q(i,j) and 100. The chance that the most likely value is above or below Q is 50%. For convenience let Q(i,j) be represented by Q for any i and j.

An example is illustrated to better understand the determination of the Q. Suppose a risk variable "negative environmental/social impact" is one of the risk variables identified for product X. The analyst thinks that there is a chance that product X will present a negative environmental impact. It was estimated that the chance that the problem will occur is greater than the chance that the problem will not occur. The first guess is that the Q will be higher than 50, since 50 represents the neutral situation. Going a little farther, the analyst feels that the chance that product X will present a negative impact would be better represented by a number closer to 50 than 100. The analyst feels confident that the Q is more likely between 50 and 75 than between 75 and 100. In the range between 50 and 75, the analyst judges that 60 is the most appropriate value to represent the risk variable. Thus, Q= 60. Note that 60 divides the interval from 0 to 100 into two judgementally equally likely parts. That is, the chance that the most likely value lies above or below 60 is 50%.

Raiffa's fractile assessment procedure, the consensus method, and the Delphi technique may be used in the determination of Q.

Risk of Product Failure

The last step is to determine the risk of product failure. The risk of product failure is the weighed average of all risk variables of the new product. The determination of risk of product failure is calculated as follows:

$$RPF = \sum_{i=1}^{k} \sum_{j=1}^{m(i)} G(i)*W(i,j)*Q(i,j) \qquad (1)$$

The product $G(i)*W(i,j)$ represents the net weight of the risk variable $V(i,j)$, and the $\sum_{i=1}^{k} \sum_{j=1}^{m(i)} G(i)*W(i,j)$ is equal to 1.

Figure 2 shows the comparative scale for quantitative and qualitative measurement of the risk.

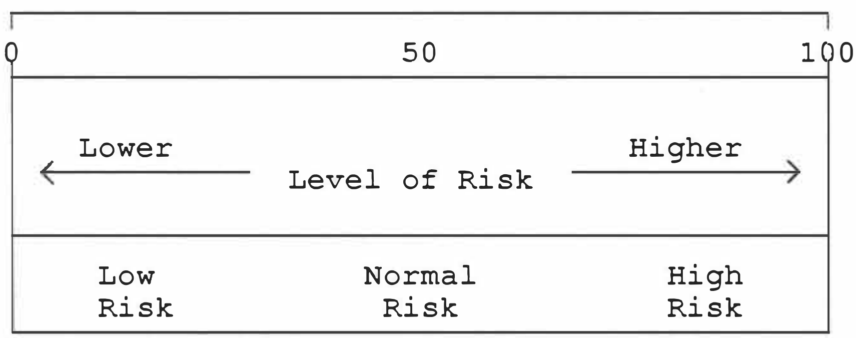


Figure 2. Comparative Scale for Quantitative and Qualitative Measurement of the Risk.

Investment Decision Making

The decision to invest or not invest in a new product is based on three input variables. The variables are the risk of product failure, the estimated project cost, and the maximum loss a company can afford in an investment. These three variables combined form a point in the investment decision matrix. The point P(x,y) is determined by taking x equal to the risk of product failure, and y equal to the ratio of the maximum loss to the project cost. The maximum loss is less than or equal to the project cost, so that the ratio is between 0 and 1. For convenience let P(x,y) be represented by P. Figure 3 shows the investment decision matrix. This matrix is divided in four regions, each with a different characteristic. Each is described in the next paragraph.

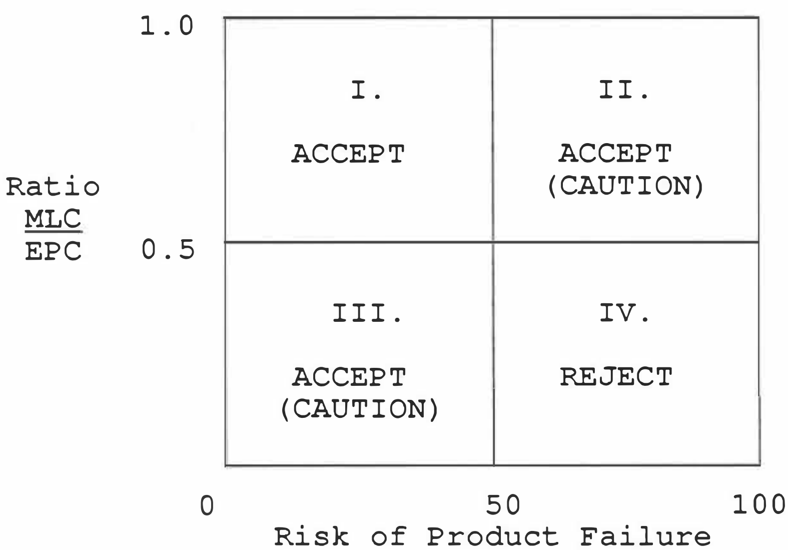


Figure 3. Investment Decision Matrix.

If point P lies in region I, the recommendation is to invest in the product. This region represents the best of the four to the investor. That is, the company can afford to lose a relatively large amount of capital for a product that presents low risk of failure. The closer the point lies to the upper left portion of the region, the more the investment is recommended. On the contrary, as the point moves to the lower right portion the recommendation to invest decreases.

If point P lies in region II or III, the recommendation is still to invest, but a more careful judgement will be required than in the case when the point lies in region I. Regions II and III present a combination of desirable and undesirable aspects. Region II presents a desirable ratio of MLC/EPC but an undesirable risk of product failure, while region III presents an undesirable ratio of MLC/EPC but a desirable level of risk. For both regions II and III the recommendation to invest becomes stronger as the point moves up and to the left, and the recommendation to invest decreases as the point moves down and to the right.

All points that lie in region IV indicate a decision to reject. This is the worst of the four regions. The company faces the decision to invest or not invest in a product that presents high risk of product failure with low ratio of MLC/EPC.

When the result obtained from the model does not satisfy the decision maker's intuitive judgement, the problem should be reanalyzed. First, the analyst should investigate whether some risk variables are missing. Second, if changes in estimated weights and most likely values are necessary, the use of sensitivity analysis may help in assigning new values. The reevaluation after the first complete estimation is an important aspect in a quantitative analysis. Usually, the reevaluated data tend to give more accurate values than the values of the first evaluation.

Illustrative Examples

Three examples are illustrated using the decision model developed in this study.

Example 1

Suppose that eight risk variables were identified for product XYZ. The corresponding groups, weights, and most likely values are:

Group 1	Group 2	Group 3
v(2)	v(1)	v(3)
v(5)	v(4)	v(6)
v(7)	v(8)	

Rearranging:

Group 1	Group 2	Group 3
V(1,1)= v(2)	V(2,1)= v(1)	V(3,1)= v(3)

V(1,2)= v(5)	V(2,2)= v(4)	V(3,2)= v(6)
V(1,3)= v(7)	V(2,3)= v(8)	

Group Weights:

Group 1	50 %
Group 2	30 %
Group 3	20 %

Variable weights and most likely values:

Var	Weight (%)	Q
V(1,1)	40	20
V(1,2)	30	50
V(1,3)	30	50
V(2,1)	50	40
V(2,2)	30	30
V(2,3)	20	50
V(3,1)	70	40
V(3,2)	30	20

$$RPF = .50*.40*20 + .50*.30*50 + .50*.30*50 + .30*.50*40 + .30*.30*30 + .30*.20*50 + .20*.70*40 + .20*.30*20$$

$$= 37.5$$

Thus, the risk of product failure is 37.5.

Let the estimated project cost be $5 million, and the maximum loss the company can afford be $3 million. Then

$$MLC/EPC = 3/5 = 0.6$$

Figure 4 shows the point P(1) in the investment decision matrix.

From the decision model proposed the product lies in region I. Thus, the investment in new product XYZ is recommended.

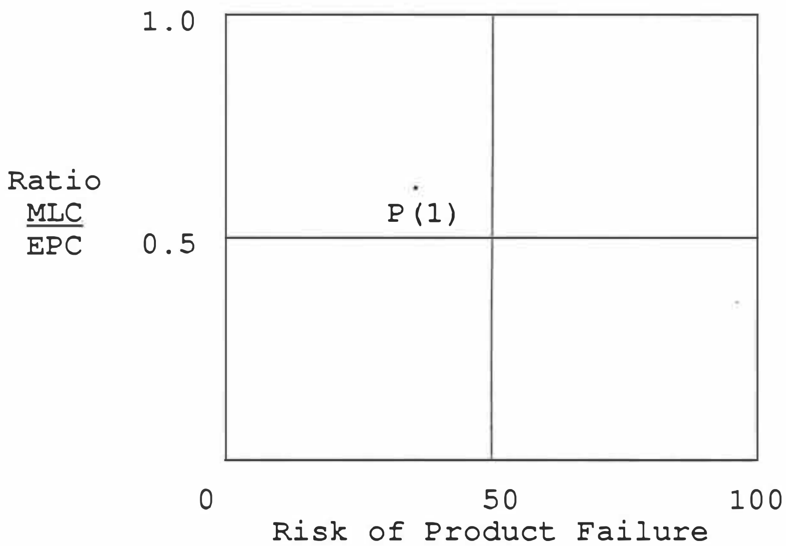


Figure 4. Localization of Point P(1) in Investment Decision Matrix.

Example 2

A total of 12 risk variables were identified for product ABC. The estimated project cost is $8 million, and the maximum loss the company can afford for this investment is $3 million. The following are groups, weights, and most likely values for the risk variables of product ABC:

Group 1	Group 2	Group 3	Group 4
v(1)	v(3)	v(4)	v(6)
v(2)	v(10)	v(5)	v(7)
v(9)		v(11)	v(8)
v(12)			

Rearranging:

Group 1	Group 2	Group 3
V(1,1)= V(1)	V(2,1)= V(3)	V(3,1)= v(4)
V(1,2)= V(2)	V(2,2)= V(10)	V(3,2)= v(5)
V(1,3)= V(9)		V(3,3)= v(11)
V(1,4)= V(12)		

Group 4

V(4,1)= v(6)
V(4,2)= v(7)
V(4,3)= v(8)

Group Weights:

Group 1	30 %
Group 2	30 %
Group 3	25 %
Group 4	15 %

Variable weights and most likely values:

Var	Weight(%)	Q
V(1,1)	40	30
V(1,2)	30	20
V(1,3)	15	20
V(1,4)	15	50
V(2,1)	50	30
V(2,2)	50	15
V(3,1)	40	70
V(3,2)	30	20
V(3,3)	30	60
V(4,1)	55	10
V(4,2)	25	25
V(4,3)	20	40

Using equation (1),

RPF = 31.3

MLC/EPC = 3/8
= 0.38

Figure 5 shows the point P(2) in the investment decision matrix.

From the decision model proposed the product lies in region III. Thus, the recommendation is to invest in product ABC, but a careful evaluation will be required before making the decision.

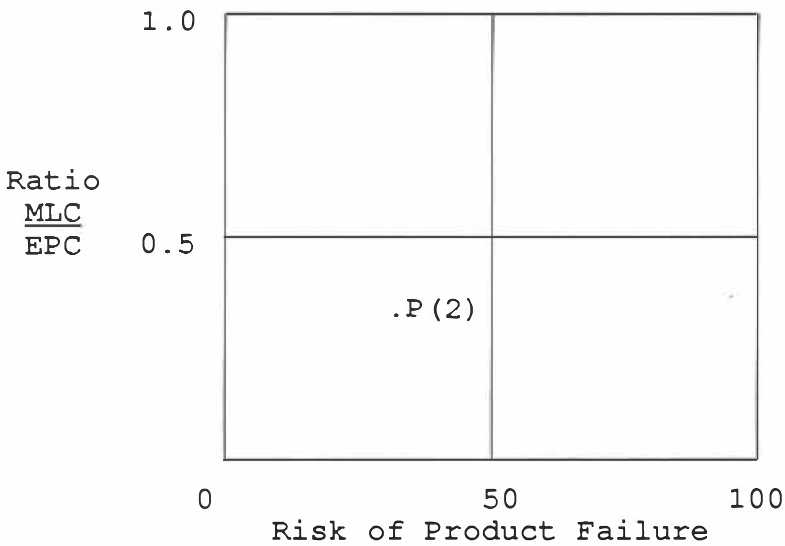


Figure 5. Localization of Point P(2) in Investment Decision Matrix.

Example 3

A total of 6 risk variables were identified for product PQR. The estimated project cost is $1.2 million, and the maximum amount the company can afford to lose is $0.48 million. The following are groups, weights, and most likely values for the risk variables of product PQR:

Groups:

Group 1	Group 2	Group 3
v(1)	v(2)	v(3)
v(4)	v(5)	
v(6)		

Rearranging:

Group 1	Group 2	Group 3
V(1,1)= v(1)	V(2,1)= v(2)	V(3,1)= v(3)
V(1,2)= v(4)	V(2,2)= v(5)	
V(1,3)= v(6)		

Group Weights:

Group 1	30 %
Group 2	50 %
Group 3	20 %

Variable weights and most likely values:

Var	Weight (%)	Q
V(1,1)	50	70
V(1,2)	30	85
V(1,3)	20	60
V(2,1)	60	75
V(2,2)	40	100
V(3,1)	100	60

Using equation (1),

RPF = 76.3

MLC/EPC = 0.48/1.20
= 0.40

Figure 6 shows the point P(3) in the investment decision matrix.

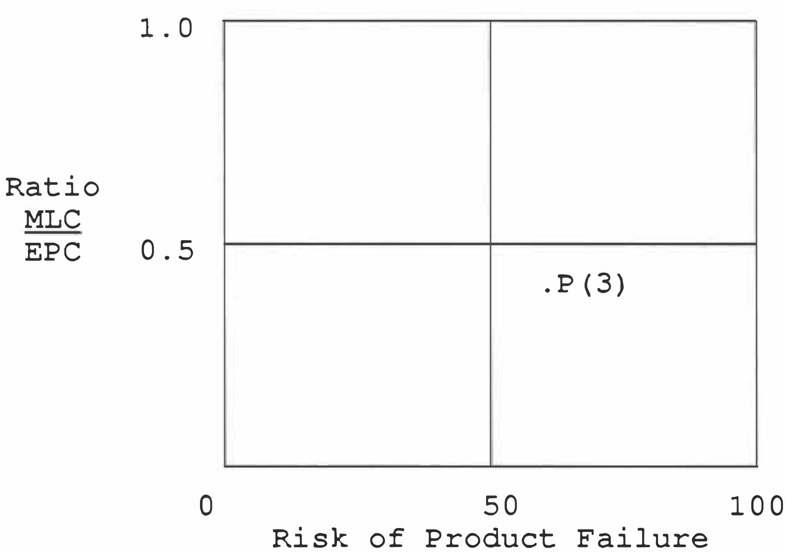


Figure 6. Localization of Point P(3) in Investment Decision Matrix.

From the decision model proposed the product lies in region IV. Thus, it is recommended not to invest in product PQR to avoid a "too" risky investment.

CHAPTER IV

IMPLEMENTATION OF THE MODEL ON COMPUTER

This chapter describes the computer program written to execute all operations of the model developed in the previous chapter. The user-friendly program was written in BASIC. All operations of the model are elementary but they are both time consuming and subject to errors when solved manually. The flow chart, program listing, a complete program output, and the instructions to use the program are furnished in appendix B.

When the computer program is loaded in a microcomputer, the user is prompted to input data. First, the program asks to input total number of variables (n), total number of groups (k), and number of variables for each group (m(i)). After each value is entered, the program asks if the value is correct. If correction is requested, the program goes back to this input position. Otherwise, the program asks for the next input data. After all m(i)s are entered, the program checks if the sum of m(i)s is equal to n, and if it is not true the program asks to reenter all values of m(i)s again.

Next, the program asks to input group weights (G(i)). After each input, if a correction is requested, the program goes back to this input position and asks to redo. If the sum of G(i)s is between 99.8 and 100.2 then the program continues. Otherwise, the program displays an error message and asks to redo. Following, the program asks to input weights for each variable (W(i,j)) by group. The process to enter the data is the same as in the previous step. For each group, after the weights for all variables of the group are entered, the program checks if the sum is between 99.8 and 100.2. If so, the program goes to the next group. Otherwise, it asks to redo.

Next, the program asks the user to enter the quantified most likely value (Q(i,j)) for each variable by group. If correction is requested, the user is prompted to reenter the value again. After all most likely values are entered, a hardcopy of input data is printed. These include n, k, m(i)s, G(i)s, W(i,j)s, net weights (G(i)*W(i,j)), and Q(i,j)s.

After the hardcopy is furnished, the program determines the risk of the product failure (RPF). Following, the program asks to enter the values of the estimated project cost (EPC), and the maximum loss the company can afford to lose in an investment (MLC). When they are given, the program finds in which region the point (P) of the product lies, and furnishes the recommendation to invest or not invest. A hardcopy of all output is furnished.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

In this last chapter the conclusions from this study are presented. Following, recommendations for further study are suggested.

Conclusions

The model developed in this study is applicable to new products which present a high probability of economic failure. The model considers two important aspects most decision analyses ignore: the risk of product failure, and the maximum loss a company can afford in an investment. These two aspects give the decision maker valuable information before making a decision. In other words, the decision maker can avoid investments in new products that present a high risk of product failure with a low maximum affordable loss.

The model employs only simple mathematics and statistics, so the decision maker can easily understand the model. An other advantage of the model is that all operations of the model can easily be implemented in a computer.

The model has weaknesses. The validity of the model

model depends on identifying all of the risk variables. Finding all the risk variables for a new product is not easy. If a major risk variable is not identified, the model may fail.

Separation of variables according to correlations is not simple. Also, the assignment of weights and most likely values for each variable is a difficult task. These are subtle concepts and the final values depend on the judgement of the analyst.

An initial goal of the study was to present the risk of product failure as a cumulative distribution function. This proved to be the most difficult part. A cumulative distribution function can be assigned to a variable when it is represented by a unit of measurement, such as time or cost. But all risk variables in this study were either subjective or presented more than one unit of measurement. In other words, some variables did not have a unit of measurement, while some others needed several units to be considered together. For example, there is no unit of measurement for the risk variable "Requirement of a major change in attitude or behavior of the user of product." The risk variable "Insufficient market research" needs several units of measurement together such as time, cost, and the quality of research. Without a single unit of measurement the assignment of a cumulative distribution function becomes difficult. This task requires a large investment in time to investigate, and consequently this study was limited to a single most likely value.

Recommendations for Future Research

The recommendation for further study is to continue to attempt to state the risk variables in the form of a cumulative distribution function (CDF) in the scale of 0 to 100. The determination of the CDF for a subjective variable is difficult. Only three points for the CDF curve can be approximated. As defined in the section Quantification of Risk Variable, 0 represents the value where the event of the risk variable will not significantly contribute to economic failure. Not significantly can be defined to mean a probability of 1% or less. This establishes CDF = 0.01. On the other hand, 100 represents the value where the event of the risk variable will significantly contribute to risk of product failure. Significantly can be defined to mean a probability of 99% or more (CDF = 0.99). The chance that the most likely value can lie above or below Q is 50%. This establishes the value at which the CDF = 0.50. The three points (A, B, and C) are shown in Figure 7. Now the determination of the CDF curve between A and B, and between B and C becomes a real challenge and a subject for further study.

Investigation of actual cases where new products introduced on the market were either failure or success is recommended. The model should be tested on the cases by simulating its application and comparing the output of the model to the actual outcome.

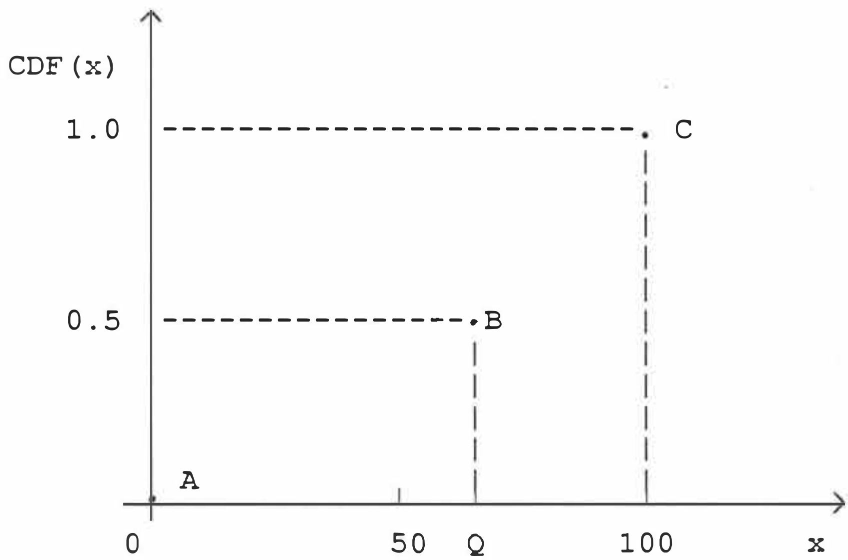


Figure 7. The Localization of Points A, B, and C.

APPENDICES

Appendix A

Raiffa's Fractile Assessment Procedure, Consensus Method, and Delphi Technique

RAIFFA'S FRACTILE ASSESSMENT PROCEDURE

The following text was extracted from the article by Hertz and Thomas (1983):

> The following example demonstrates the implementation of this approach. It illustrates the actual assessment of the probability distribution for the price per thousand Egg'N Foam cartons for the first year of the new product launch. The series of questions might be as follows:
>
> ***Analyst***: Can you give me a value of the price (per thousand cartons) such that you feel there is only a very small chance, say 1%, that it will be exceeded during the first year of the Egg'N Foam launch? (Note that this establishes the value at which the CDF = 0.99.)
>
> ***Manager***: I guess I would say $27.
>
> ***Analyst***: Can you also give me a value of the price (per thousand cartons) such that you feel there is only a very small chance, say 1%, that it will be bellow that value during the first year of the launch? (Note that this establishes the value at which the CDF = 0.01.)
>
> ***Manager***: There is no way that it would go bellow $22.
>
> ***Analyst***: Can you give me a value for price that you feel has a 50% chance of being exceeded during the first year? (Note that this establishes the point at which the CDF = 0.50.)
>
> ***Manager***: Now, that's a hard thing to conceive. I suppose about $25.
>
> ***Analyst***: Are you sure about that? Would you find it extremely hard to choose between a bet on the interval above $25 ($25-$27) and on the interval bellow $25 ($22-$25)? (Note that this is a consistency check to ensure that $25 is the 0.50 fractile or the 50th percentile of the distribution.)
>
> ***Manager***: Yes.

> ***Analyst***: Now, suppose that the actual price during the first year will be bellow $25. Can you give me a value for price in the range of $22-$25 that you feel has a 50% chance of being exceeded?
>
> ***Manager***: Say $24. (Note that this establishes $24 as the 0.25 fractile, i.e., the value of price at which the CDF = 0.25.)
>
> ***Analyst***: Finally, given that the true value of the price during the year will exceed $25, can you give me a value for price that you feel has a 50% chance of being exceeded?
>
> ***Manager***: Well, I guess that I am beginning to understand what you are after now. My indifference point is about $26. (Note that this establishes $26 as the price at which the CDF = 0.75.) (p. 22)

CONSENSUS METHOD

The following was extracted from the text by Maxim and Cook (1970):

> Consensus techniques operate generally as follows: Knowledgeable individuals-or experts if you prefer-are asked to provide information on critical parameters of interest. That information consists of numerical estimates together with whatever data exist to support those estimates. The material is presented and discussed openly in a series of group meetings in an attempt to arrive at a consensus. Between meetings, participants are free to rethink the problem, acquire additional supporting data, reanalyze their own or other participants' data, and revise their estimates. The process continues until a group consensus is reached or it is agreed that a consensus is impossible. (p. 37)

DELPHI TECHNIQUE

The following was extracted from the text by Maxim and Cook (1970):

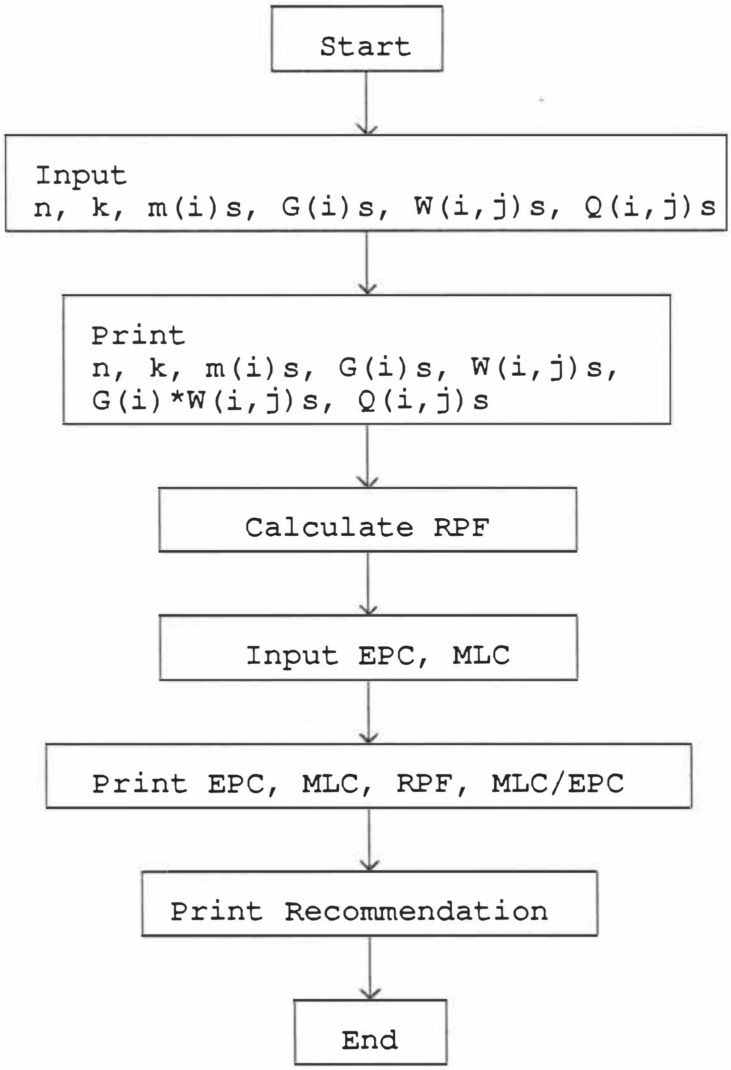
> The Delphi technique incorporates three main features to eliminate disadvantages of the consensus approach; they are anonimity, statistical summarization of group response, and controlled feedback. One way in which a Delphi exercise might be run is as follows: A questionnaire is sent to all participants of the panel of experts; it defines the variable to be estinated and also key assumptions or ground rules that the participants should take to be the givens of the problem. Each participant then formulates his estimate (either as single point or, preferably, as a probabilty distribution). The participants are also asked to identify any other assumptions that underlie their analysis. The responses are then summarized statistically by the analyst who is conducting the exercise. Typically, the summarization includes the distribution of all results and a statement of where each respondent's estimate falls in relation to other estimates. Respondents are asked to rethink the problem and submit revised estimates if they think revision is appropriate. (pp. 37-38)

Appendix B

Computer Program

COMPUTER PROGRAM

Flow Chart



Note: The abbreviations used in this flow chart are the same as in the text.

Program Listing

```
100 REM      ***********************************************************
110 REM      *                                                         *
120 REM      *                                                         *
130 REM      *     APPLICATION OF RISK ANALYSIS IN INVESTMENT          *
140 REM      *                                                         *
150 REM      *          DECISION MAKING FOR NEW PRODUCTS               *
160 REM      *                                                         *
170 REM      *                                                         *
180 REM      ***********************************************************
190 REM
200 REM
210 REM
220 REM                      Date: November, 1989
230 REM
240 REM
250 REM
260 REM
270 REM                              by
280 REM
290 REM                          Chul Paik
300 REM
310 REM
320 REM
330 REM
340 REM
350 REM
360 REM
370 REM
380 REM
390 REM
400 REM
410 REM
420 CLS
430 PRINT"  "
440 PRINT"  "
450 PRINT"     ***********************************************************"
460 PRINT"     *                                                         *"
470 PRINT"     *                                                         *"
480 PRINT"     *     APPLICATION OF RISK ANALYSIS IN INVESTMENT          *"
490 PRINT"     *                                                         *"
500 PRINT"     *          DECISION MAKING FOR NEW PRODUCTS               *"
510 PRINT"     *                                                         *"
520 PRINT"     *                                                         *"
530 PRINT"     ***********************************************************"
540 LOCATE 22,40: INPUT" Press <Return> to continue. "; OK$
550 DIM V(50,50), G(50), M(50), W(50,50), EW(50,50), Q(50,50)
560 CLS
570 LOCATE 5,10: PRINT"       This program executes all operations of the"
580 LOCATE 6,10: PRINT"       investment decision model."
590 LOCATE 16: PRINT"  Make sure that the printer is turned on."
600 LOCATE 22,40: INPUT" Press <Return> to continue. "; OK$
610 CLS
620 PRINT"  "
630 PRINT"  "
640 INPUT"  Enter the total number of variables: "; N
650 INPUT"  Is it correct (Y/N)"; CC$
660 IF CC$="N" OR CC$="n" THEN GOTO 630
670 IF CC$="Y" OR CC$="y" THEN GOTO 690
```

```
680 GOTO 650
690 PRINT"  "
700 PRINT"  "
710 PRINT"  "
720 INPUT"  Enter the total number of groups: "; K
730 INPUT"  Is it correct (Y/N)"; CC$
740 IF CC$="N" OR CC$="n" THEN GOTO 710
750 IF CC$="Y" OR CC$="y" THEN GOTO 770
760 GOTO 730
770 CLS
780 PRINT"  "
790 PRINT"  "
800 PRINT"  Enter the number of variables in a group:"
810 SUM = 0
820 FOR I=1 TO K
830 PRINT"  "
840 PRINT"  Group";I;
850 INPUT M(I)
860 INPUT"  Is it correct (Y/N)"; CC$
870 IF CC$="N" OR CC$="n" THEN GOTO 830
880 IF CC$="Y" OR CC$="y" THEN GOTO 900
890 GOTO 860
900 SUM = SUM + M(I)
910 NEXT I
920 IF SUM = N THEN GOTO 980
930 PRINT"  "
940 PRINT" The total number of variables is not equal to n."
950 PRINT" Please, check the values, and when ready"
960 INPUT" press <return>. ";OK$
970 GOTO 770
980 CLS
990 PRINT"  "
1000 PRINT"  "
1010 PRINT"  Enter the weights to each group. Give in percentage (%)."
1020 PRINT"  Remember that the sum of all weights is equal to 100%."
1030 PRINT"  "
1040 PRINT"  "
1050 SUM = 0
1060 FOR I=1 TO K
1070 PRINT"  "
1080 PRINT"  Group";I;
1090 INPUT G(I)
1100 INPUT"  Is it correct (Y/N)"; CC$
1110 IF CC$="N" OR CC$="n" THEN GOTO 1070
1120 IF CC$="Y" OR CC$="y" THEN GOTO 1140
1130 GOTO 1100
1140 SUM = SUM + G(I)
1150 NEXT I
1160 IF SUM > 99.8 AND SUM < 100.2 THEN GOTO 1230
1170 PRINT"  "
1180 PRINT"  "
1190 PRINT"  The sum is not close enough to 100%. Therefore some input(s)"
1200 PRINT"  must be incorrect. Please, check the values, and when"
1210 INPUT"  ready press <return> to make corrections. ";OK$
1220 GOTO 980
1230 CLS
1240 PRINT"  "
1250 PRINT"  "
1260 PRINT"  Enter the weights to each variable in a group. Give in"
1270 PRINT"  percentage (%) after the variable appears. Remember that"
1280 PRINT"  the sum of all weights of variables in a group is equal"
1290 PRINT"  to 100%."
1300 PRINT"  "
1310 FOR I=1 TO K
1320 PRINT"  "
1330 PRINT"  "
```

```
1340 PRINT"  "
1350 PRINT"  "
1360 PRINT"  Group"; I
1370 PRINT"  "
1380 SUM = 0
1390 FOR J=1 TO M(I)
1400 PRINT"  "
1410 PRINT"  V(";I;",";J;")";"     weight:";
1420 INPUT W(I,J)
1430 INPUT"  Is it correct (Y/N)"; CC$
1440 IF CC$="N" OR CC$="n" THEN GOTO 1400
1450 IF CC$="Y" OR CC$="y" THEN GOTO 1470
1460 GOTO 1430
1470 SUM = SUM + W(I,J)
1480 NEXT J
1490 IF SUM > 99.8 AND SUM < 100.2 THEN GOTO 1560
1500 PRINT"  "
1510 PRINT"  "
1520 PRINT"  The sum is not close enough to 100%. Therefore some input(s)"
1530 PRINT"  must be incorrect. Please, check the values, and when"
1540 INPUT"  ready press <return> to make corrections. ";OK$
1550 GOTO 1320
1560 NEXT I
1570 FOR I=1 TO K
1580 FOR J=1 TO M(I)
1590 EW(I,J)= G(I)*W(I,J)/100
1600 NEXT J
1610 NEXT I
1620 CLS
1630 PRINT"  "
1640 PRINT"  "
1650 PRINT"  For each variable enter the most likely value:"
1660 FOR I=1 TO K
1670 FOR J=1 TO M(I)
1680 PRINT"  "
1690 PRINT"  "
1700 PRINT"  V(";I;",";J;")"
1710 PRINT" "
1720 INPUT"  MOST LIKELY VALUE = "; Q(I,J)
1730 INPUT"  Is it correct (Y/N)";CC$
1740 IF CC$="N" OR CC$="n" THEN GOTO 1710
1750 IF CC$="Y" OR CC$="y" THEN GOTO 1770
1760 GOTO 1730
1770 NEXT J
1780 NEXT I
1790 CLS
1800 LOCATE 10: PRINT"                          WAIT...."
1810 LPRINT"  "
1820 LPRINT"  *******************************************************"
1830 LPRINT"  *                                                     *"
1840 LPRINT"  *                                                     *"
1850 LPRINT"  *    APPLICATION OF RISK ANALYSIS IN INVESTMENT       *"
1860 LPRINT"  *                                                     *"
1870 LPRINT"  *         DECISION MAKING FOR NEW PRODUCTS            *"
1880 LPRINT"  *                                                     *"
1890 LPRINT"  *                                                     *"
1900 LPRINT"  *******************************************************"
1910 LPRINT"  "
1920 LPRINT"  "
1930 LPRINT"  "
1940 LPRINT"  "
1950 LPRINT"  Total number of variables:"; N
1960 LPRINT" "
1970 LPRINT"  Total number of groups:"; K
1980 LPRINT"  "
1990 LPRINT"  "
```

```
2000 FOR I=1 TO K
2010 LPRINT"  "
2020 LPRINT"  GROUP";I
2030 FOR J=1 TO M(I)
2040 LPRINT"     V(";I;",";J;")"
2050 NEXT J
2060 NEXT I
2070 LPRINT"  "
2080 LPRINT"  "
2090 LPRINT"  "
2100 LPRINT"  Group Weights:"
2110 LPRINT"  "
2120 FOR I=1 TO K
2130 LPRINT"     GROUP"; I; "    ";
2140 LPRINT USING "###.#"; G(I);
2150 LPRINT" %"
2160 NEXT I
2170 LPRINT"  "
2180 LPRINT"  "
2190 LPRINT"  "
2200 LPRINT"  Variable Weights:"
2210 FOR I=1 TO K
2220 LPRINT"  "
2230 LPRINT"  GROUP"; I
2240 FOR J=1 TO M(I)
2250 LPRINT"     V(";I;",";J;")";
2260 LPRINT"  ";
2270 LPRINT USING "###.#";W(I,J);
2280 LPRINT" %"
2290 NEXT J
2300 NEXT I
2310 LPRINT"  "
2320 LPRINT"  "
2330 LPRINT"  "
2340 LPRINT"  Equivalent Weight of the Variables:"
2350 FOR I=1 TO K
2360 LPRINT"  "
2370 FOR J=1 TO M(I)
2380 LPRINT"     V(";I;",";J;") = ";
2390 LPRINT USING "###.#";EW(I,J);
2400 LPRINT" %"
2410 NEXT J
2420 NEXT I
2430 LPRINT"  "
2440 LPRINT"  "
2450 LPRINT"  "
2460 LPRINT"  Most Likely Value of the Variables:"
2470 FOR I=1 TO K
2480 LPRINT"  "
2490 FOR J=1 TO M(I)
2500 LPRINT"     V(";I;",";J;") = ";
2510 LPRINT USING "###";Q(I,J)
2520 NEXT J
2530 NEXT I
2540 RPF = 0
2550 FOR I=1 TO K
2560 FOR J=1 TO M(I)
2570 RPF=RPF+EW(I,J)*Q(I,J)/100
2580 NEXT J
2590 NEXT I
2600 CLS
2610 PRINT"  "
2620 PRINT"  "
2630 PRINT"  Enter the value of the best estimation of"
2640 INPUT"  the project cost (US$): "; EPC
2650 INPUT"  Is it correct (Y/N)", CC$
```

```
2660 IF CC$="N" OR CC$="n" THEN GOTO 2620
2670 IF CC$="Y" OR CC$="y" THEN GOTO 2690
2680 GOTO 2650
2690 PRINT"  "
2700 PRINT"  "
2710 PRINT"  Enter the maximum loss the company can"
2720 INPUT"  afford in an investment (US$): "; MLC
2730 INPUT"  Is it correct (Y/N)", CC$
2740 IF CC$ ="N" OR CC$ = "n" THEN GOTO 2700
2750 IF CC$="Y" OR CC$="y" THEN GOTO 2770
2760 GOTO 2730
2770 PP=MLC/EPC
2780 IF RPF < 50 AND PP > .5 THEN REG = 1
2790 IF RPF > 50 AND PP > .5 THEN REG = 2
2800 IF RPF < 50 AND PP < .5 THEN REG = 3
2810 IF RPF > 50 AND PP < .5 THEN REG = 4
2820 CLS
2830 PRINT"                         Investment Decision"
2840 PRINT"                         -------------------"
2850 PRINT"  "
2860 PRINT"  "
2870 PRINT"  The estimated project cost (US$):"; EPC
2880 PRINT"  The maximum loss the company can afford (US$):"; MLC
2890 PRINT"  "
2900 PRINT"  Risk of product failure: ";
2910 PRINT USING "###.#";RPF
2920 PRINT"  "
2930 PRINT"  "
2940 PRINT"  MLC/EPC =";
2950 PRINT USING "#.##"; PP
2960 PRINT"  "
2970 PRINT"  "
2980 IF REG =1 THEN GOTO 3020
2990 IF REG =2 THEN GOTO 3060
3000 IF REG =3 THEN GOTO 3120
3010 IF REG =4 THEN GOTO 3180
3020 PRINT" The product lies in region I"
3030 PRINT"  "
3040 PRINT" Recommendation:  INVEST"
3050 GOTO 3220
3060 PRINT" The product lies in region II"
3070 PRINT"  "
3080 PRINT"  Recommendation:  INVEST, BUT CAREFUL."
3090 PRINT"  A more careful analysis may be required"
3100 PRINT"  before making the decision."
3110 GOTO 3220
3120 PRINT" The product lies in region III"
3130 PRINT"  "
3140 PRINT"  Recommendation:  INVEST, BUT CAREFUL."
3150 PRINT"  A more careful analysis may be required"
3160 PRINT"  before making the decision."
3170 GOTO 3220
3180 PRINT"  The product lies in region IV"
3190 PRINT"  "
3200 PRINT"  Recommendation:  DO NOT INVEST."
3210 PRINT"  The investment is too risky."
3220 PRINT"  "
3230 PRINT"  "
3240 PRINT"  "
3250 PRINT"                       END OF THE PROGRAM"
3260 LPRINT"  "
3270 LPRINT"  "
3280 LPRINT"  "
3290 LPRINT"  "
3300 LPRINT"  "
3310 LPRINT"  Investment Decision"
```

```
3320 LPRINT"  ------------------"
3330 LPRINT"  "
3340 LPRINT"  "
3350 LPRINT"  The estimated project cost (US$):"; EPC
3360 LPRINT"  The maximum limit of loss (US$):"; MLC
3370 LPRINT"  "
3380 LPRINT"  "
3390 LPRINT"  Risk of product failure: ";
3400 LPRINT USING "###.#"; RPF
3410 LPRINT"  "
3420 LPRINT"  MLC/EPC =";
3430 LPRINT USING "#.##"; PP
3440 LPRINT"  "
3450 LPRINT"  "
3460 LPRINT"  "
3470 IF REG = 1 THEN GOTO 3510
3480 IF REG = 2 THEN GOTO 3550
3490 IF REG = 3 THEN GOTO 3610
3500 IF REG = 4 THEN GOTO 3670
3510 LPRINT"  The product lies in region I"
3520 LPRINT"  "
3530 LPRINT"  Recommendation:  INVEST"
3540 GOTO 3710
3550 LPRINT"  The product lies in region II"
3560 LPRINT"  "
3570 LPRINT"  Recommendation:  INVEST, BUT CAREFUL."
3580 LPRINT"  A more careful analysis may be required"
3590 LPRINT"  before making the decision."
3600 GOTO 3710
3610 LPRINT"  The product lies in region III"
3620 LPRINT"  "
3630 LPRINT"  Recommendation:  INVEST, BUT CAREFUL."
3640 LPRINT"  A more careful analysis may be required"
3650 LPRINT"  before making the decision."
3660 GOTO 3710
3670 LPRINT"  The product lies in region IV"
3680 LPRINT"  "
3690 LPRINT"  Recommendation:  DO NOT INVEST."
3700 LPRINT"  The investment is too risky."
3710 FOR I=1 TO 6
3720 LPRINT"  "
3730 NEXT I
3740 LPRINT"    ** END OF THE OUTPUT **"
3750 END
3760 SYSTEM
```

Program Output

```
*****************************************************
*                                                   *
*                                                   *
*    APPLICATION OF RISK ANALYSIS IN INVESTMENT     *
*                                                   *
*         DECISION MAKING FOR NEW PRODUCTS          *
*                                                   *
*                                                   *
*****************************************************


Total number of variables: 8

Total number of groups: 3


GROUP 1
  V( 1 , 1 )
  V( 1 , 2 )
  V( 1 , 3 )

GROUP 2
  V( 2 , 1 )
  V( 2 , 2 )
  V( 2 , 3 )

GROUP 3
  V( 3 , 1 )
  V( 3 , 2 )


Group Weights:

  GROUP 1      50.0 %
  GROUP 2      30.0 %
  GROUP 3      20.0 %


Variable Weights:

GROUP 1
  V( 1 , 1 )    40.0 %
  V( 1 , 2 )    30.0 %
  V( 1 , 3 )    30.0 %

GROUP 2
  V( 2 , 1 )    50.0 %
  V( 2 , 2 )    30.0 %
  V( 2 , 3 )    20.0 %

GROUP 3
  V( 3 , 1 )    70.0 %
  V( 3 , 2 )    30.0 %
```

Equivalent Weight of the Variables:

```
V( 1 , 1 ) =  20.0 %
V( 1 , 2 ) =  15.0 %
V( 1 , 3 ) =  15.0 %

V( 2 , 1 ) =  15.0 %
V( 2 , 2 ) =   9.0 %
V( 2 , 3 ) =   6.0 %

V( 3 , 1 ) =  14.0 %
V( 3 , 2 ) =   6.0 %
```

Most Likely Value of the Variables:

```
V( 1 , 1 ) =  20
V( 1 , 2 ) =  50
V( 1 , 3 ) =  50

V( 2 , 1 ) =  40
V( 2 , 2 ) =  30
V( 2 , 3 ) =  50

V( 3 , 1 ) =  40
V( 3 , 2 ) =  20
```

Investment Decision

The estimated project cost (US$): 5000000
The maximum limit of loss (US$): 3000000

Risk of product failure: 37.5

MLC/EPC =0.60

The product lies in region I

Recommendation: INVEST

** END OF THE OUTPUT **

<u>Instructions to Use the Program</u>

This user-friendly computer program, written in BASIC, is very simple and easy to use. To run the program, follow the steps provided.

1. Turn on the IBM/PC or compatible with diskette inserted.

2. When A> is shown on the screen, type BASIC and <return>.

3. Press F3 and type PROG and <return> (or type LOAD"PROG and <return>.)

4. Press F2 (or type RUN and <return>).

5. The following figure appears on the screen:

```
************************************************
*                                              *
*  APPLICATION OF RISK ANALYSIS IN INVESTMENT  *
*                                              *
*       DECISION MAKING FOR NEW PRODUCTS       *
*                                              *
************************************************






                      Press <return> to continue. ?
```

6. Press <return> to continue.

7. The following figure appears on the screen:

This program executes all operations of the investment decision model.

Make sure that the printer is turned on.

Press <return> to continue. ?

8. Turn on the printer.
9. Press <return> to continue.
10. Input the values. After each input press <return>.
11. Just follow the instructions to input data or to make corrections.
12. Different screens will be displayed. Just follow the instructions.
13. When all input data are furnished, the program will give a complete output.
14. When all output is furnished, turn off the computer and the printer. Do not forget the diskette in the drive.

Important notice:

The program will "crash" if the printer is not turned on when running the program, or improper data are inserted. In this case, wait for a moment until "Ok" appears on the screen. Then press F2 to begin again, and follow the instructions from step 5. If "Ok" does not appear soon, then turn off the computer, and turn it on again. In this case, follow the steps from the beginning.

BIBLIOGRAPHY

Buck, J. R. (1982, Nov.). Risk analysis method can help make firm's investment less of a gamble. Industrial Engineering, 14, 35-41.

Cooper, R. G. (1975). Why new industrial products fail. Industrial Marketing Management, 4, 315-326.

Cooper, R. G. (1985). Industrial firm's new product strategies. Journal of Business Research, 13, 107-121.

Cooper, R. G., & More, R. A. (1979). Modular risk management: An applied example. R & D Management, 9, 93-99.

Evans, D. A. (1987, Summer). Investment decision making under uncertainty: Potential environmental/social impacts of new products. The Engineering Economist, 32, 263-280.

Heany, D. F. (1983, Spring). Degrees of product innovation. The Journal of Business Strategy, 3, 3-14.

Hertz, D. B. (1979, Sep.-Oct.). Risk analysis in capital investment. Harvard Business Review, 57, 169-181.

Hertz, D. B., & Thomas, H. (1983). Risk analysis and its application. New York: John Wiley.

Hertz, D. B., & Thomas, H. (1983, Winter). Decision and risk analysis in a new product and facilities planning problem. Sloan Management Review, 24, 17-31.

Hosseini, J. (1986, Mar.-Apr.). Decision analysis and its application in the choice between two wildcat oil ventures. Interfaces, 16, 75-85.

Link, P. L. (1987). Keys to new product success and failure. Industrial Marketing Management, 16, 109-118.

Maxim, L. D., & Cook Jr., F. X. (1972). Financial risk analysis. New York: American Management Association.

McIntyre, S. H., & Statman, M. (1982, May-June). Managing the risk of new product development. Business Horizons, 25, 51-55.

More, R. A. (1978). Primary and secondary market information for new industrial products. Industrial Marketing Management, 7, 153-160.

More, R. A. (1982). Risk factors in accepted and rejected new industrial products. Industrial Marketing Management, 11, 9-15.

Park, C. S. (1987, Winter). The Mellin transform in probabilistic cash flow modeling. The Engineering Economist, 32, 115-134.

Pouliquen, L. Y. (1970). Risk analysis in project appraisal. Washington, DC: International Bank for Reconstruction and Development.

Rappaport, A. (1967, July). Sensitivity analysis in decision making. The Accounting Review, 42, 441-456.

Silverman, A. R. (1986, Aug.). How to implement risk analysis system. Journal of systems Management, 37, 6-10.

Taha, H. A. (1987). Operations research: An introduction, 4th ed. New York: MacMillan.

Weinberger, M. G., & Romeo, J. B. (1989, Jan-Feb). The impact of negative product news. Business Horizons, 32, 44-50.