

MGT/DT/1

INDEXED

Administrative Management



*decision*

DECISION TREES

## 1. INTRODUCTION

Perhaps the one area of contemporary management interest which has in later years received the greatest attention is that which is labelled "Management Science".

This area contains mathematical and quantitative techniques which are now of key importance in management decision-making and includes the application of such studies as statistics, mathematics, computing and operational research.

One of the most important functions of a manager is to make decisions. He may very well spend most of his time communicating, instructing, justifying, checking and so on, but he also plays an important role in the organization as a decision-maker. However, if one asks a manager to explain and quantify how he arrives at an important decision, it is quite likely that he is unable to verbalise this process. Instead of solving the problem by a conscious, step-by-step, logical reasoning, he relies on his intuition, or what one often hears referred to as managerial judgment.

The intuitive manager has developed his judgment over a considerable period of time and he will often regard it as one of his primary assets. Intuition has the very real advantage of permitting quick decisions in the face of both uncertainty and ambiguity, it meets the constraints of knowledge of the environment, time and cost, and it is therefore hardly surprising that managers often find the sort of deliberate and logical methods inherent in quantitative methods for decision-making less than welcome. To the manager who is used to relying solely on his intuition and experience these methods may appear untrustworthy, beside the point, and most important, quite unnecessary. Whereas there can be little doubt that intuition and managerial judgment developed through years of experience have a very real contribution to make to the organization, it is equally obvious that

management can improve its decision-making by bettering the techniques it applies and also by improving its general understanding and approach to the decision problem itself. What is wanted is an approach which is both effective and likely to lead to decisions consistent with the goals of the organization.

The purpose of this lecture is to acquaint you with the concept of Decision Trees and to show you how the application of this technique may be used to improve decision making.

The following may be taken as a summary of its use and advantages

VISUAL 1

## 2. A SIMPLE DECISION TREE

In order to describe the characteristics of this technique in its simplest form, we will consider the following example:

Suppose you are at a party which is just in the process of breaking up. You have had a few drinks and you are trying to make up your mind what to do about transportation home. Two alternatives are open to you, (1) you may drive yourself in your own car, or (2) you may leave the car and take a taxi. (Walking is out of the question as you live more than 5 miles away and it is raining) Feeling quite sober, you would no doubt have chosen to drive your own car back, if it had not been for the fact that the police in the area had recently been quite busy at night with their "breathalysers".

The chances of getting involved in a police check are fairly small, but if you were checked it might mean losing your licence and a heavy fine. On the other hand, if you decide on the taxi this would not only mean a charge of say \$5, but also the inconvenience of having to collect your car the next day.

In the form of a Decision Tree, this situation can be laid out as follows:

VISUAL 2

It can be seen that whereas the Decision Tree contains the same information as described in the example, it seeks to break down the problem into its various components and to restructure it.

The tree is made up of a series of nodes and branches. Square nodes denotes action or decision points and circular nodes denotes chance events. The chance event represent outcomes over which the decision-maker has no control, i.e. the event "Police check" - "No police check" occurs for both actions "Take taxi" and "Drive home".

Associated with each combination of alternative actions and chance events is a result of "payoff", shown at the right of the terminal forks in the diagram.

### 3. EVALUATION WITH MONETARY VALUES

Normally Decision Trees are not used in order to consider intangibles like happiness or feelings of guilt, as in the above example.

In making decisions, the decision maker must take account of costs, probabilities associated with chance events, and returns likely to accrue, and these financial data are usually the deciding factors.

Let us, therefore, continue our previous example, but this time analyse it purely on monetary grounds and disregard the intangible effects of any mental states due to any particular outcome or course of action.

We will assume that the cost of driving your own car home is negligible and that if you are checked by the police you will be fined \$200. Assume further that there is only a 1 in 20 chance of the police actually checking cars that night. This means that the probability that the police are not checking is 19/20, as the total of the probabilities leading from a chance event node must equal 1,

in order to take account of all possible states of nature

This situation can then be laid out as shown

VISUAL 3

We will base the evaluation on the Expected Monetary Value (EMV) of the outcomes. This is the weighted average of the possible outcomes anticipated from a particular course of action. (Value times its corresponding probability).

Using this it will enable us to substitute each event fork by a single number.

VISUAL 4

If our aim is to minimise the expected value of costs, we would choose to take a taxi home after the party. This decision would be consistent with our objective in that it has evaluated in a deliberate and logical way the various choices, risks and monetary values involved.

(As a small digression here, it could be argued that it is on this basis, i.e. on how the decisions are made, rather than on the outcome of decisions that performance evaluation should be made. For example, in our case, if you decide to take the taxi and on the way home you get involved in a collision in such a way that you get injured, the outcome would be bad, but the decision to take a taxi would be just as good.)

#### 4. A PRACTICAL APPLICATION

Now to illustrate the more practical applications of Decision Trees, I will continue on the case of the Smallpox versus the Malaria eradication projects which you will recall from the previous lecture.

## VISUAL 5

You will remember that it was found that the Smallpox project (SX) had the highest Benefit/Cost ratio, and that this project therefore would be the one to recommend.

## VISUAL 6

These projects were however evaluated without any regard to the fact that the future is uncertain, and that the various projects have a different likelihood of succeeding.

To make this example somewhat more realistic we will assume that you first will have to make a feasibility study on the various projects. On the basis of the findings of this study you can proceed to make an application for financing from international sources, say the World Bank.

There is however, only sufficient local funds to do one feasibility study (i.e. either on Smallpox or on Malaria). The cost of each is however equal (\$5,000)

From reviews and studies of similar projects previously undertaken elsewhere, you know that the probability of success of the smallpox programme is about 80% whereas the malaria programmes have a chance of success of 90% and 75% respectively for the indoor spraying and the genetic control. (It should be noted here that these probabilities have been selected for illustrative purposes only).

You further assess the chances of getting financing for the smallpox programme as 70% and 80% for the malaria, regardless of method.

Now, faced with these considerations (and remembering the conclusions of your Benefit/Cost analysis) what do you do?

How can you make a logical and step-by-step analysis of all alternatives, to arrive at an optimal strategy?

The above problem can be displayed in the form of a decision tree

VISUAL 7

Filling in the discounted values of cost and benefits (from Visual 6) to the various outcomes and alternatives, we get the following

VISUAL 8

VISUAL 9

We now start evaluating this tree by computing Expected Monetary Values (EMV) for each chance event (outcome x probability). We usually do this by "rolling back" the tree, i.e. we start from the right and work our way backwards through the tree.

The EMV of a decision point (choose spraying or genetic control) obviously becomes the EMV of the most attractive alternative, as one here has a choice of action.

The tree is now reduced as follows:

VISUAL 10

Completing the evaluation in the same manner, we arrive at the optimal strategy to be pursued as shown

VISUAL 11

A ranking of the 3 alternative projects, according to method of analysis used would give:

VISUAL 12

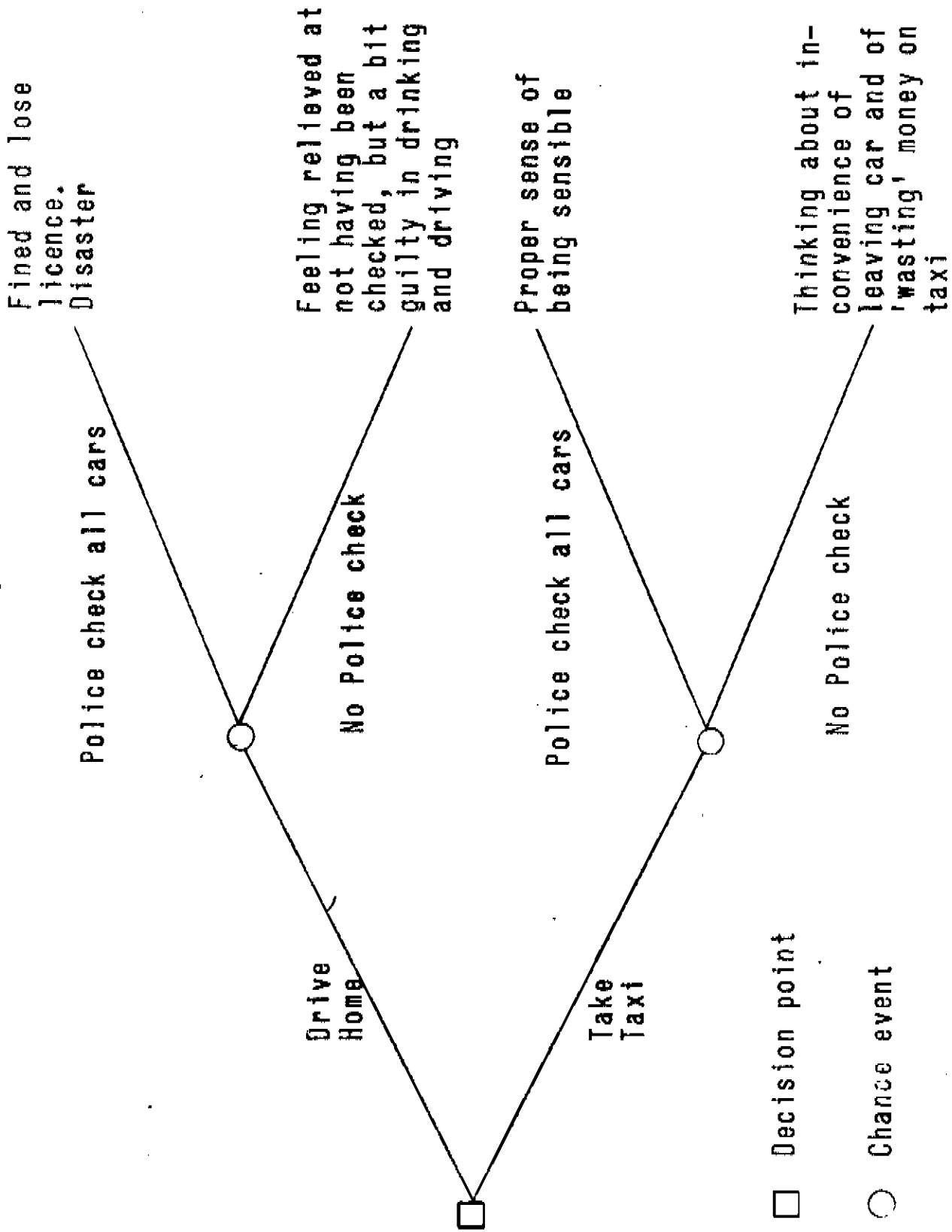
5. FINAL NOTE

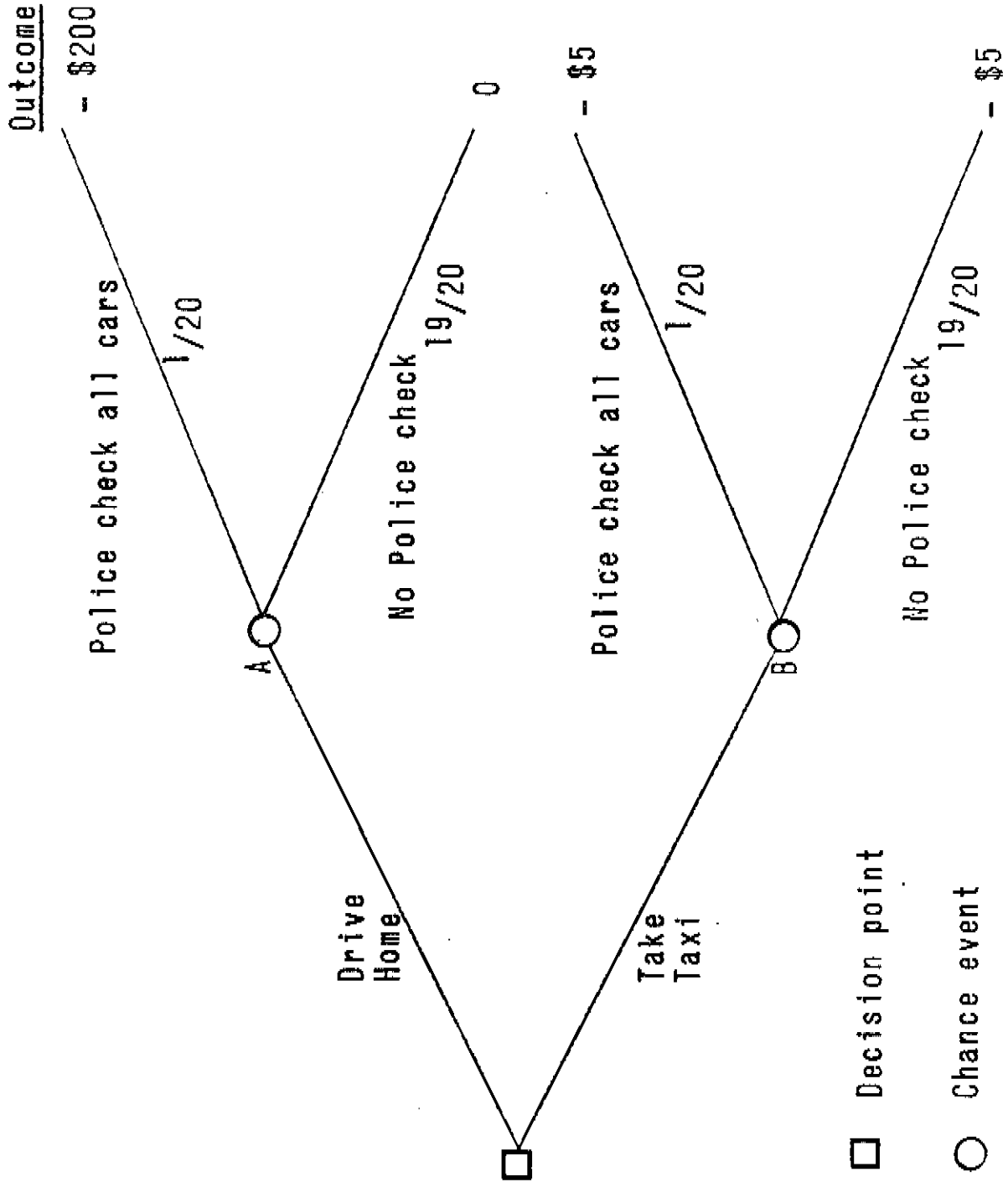
The technique of Decision Trees can usually be applied without any great difficulties to most complex problems, although the identification of possible alternatives and outcomes (with associated probabilities or probability distributions) is never as clear-cut as in this example.

It is however an extremely flexible and powerful tool and will, if properly applied, always show superiority over other methods, simply because it deals with the elements of chance and uncertainty more effectively than any alternative method.

DECISION TREES:

1. INCORPORATE THE ELEMENTS OF CHANGE AND UNCERTAINTY IN THE EVALUATION OF COMPLEX PROBLEMS.
2. DISPLAY THE VARIOUS COURSES OF ACTION OPEN TO THE DECISION MAKER IN A LOGICAL AND SEQUENTIAL MANNER.
3. FACILITATE COMMUNICATION BETWEEN THE ANALYST AND THE DECISION MAKER.





Mathematically, the EMV can be expressed as:

$$EMV = \sum X Px$$

Where X = monetary value of one event branch

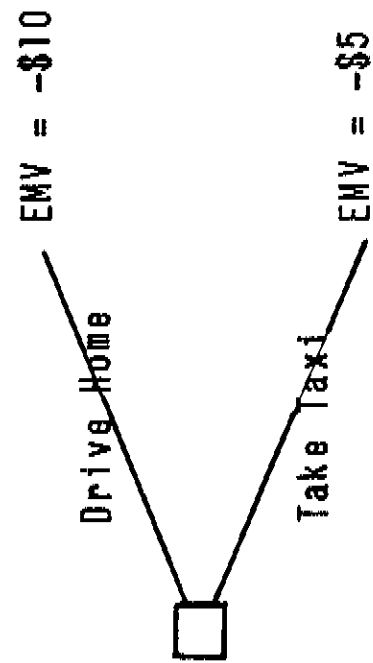
Px = probability of occurrence of this event branch

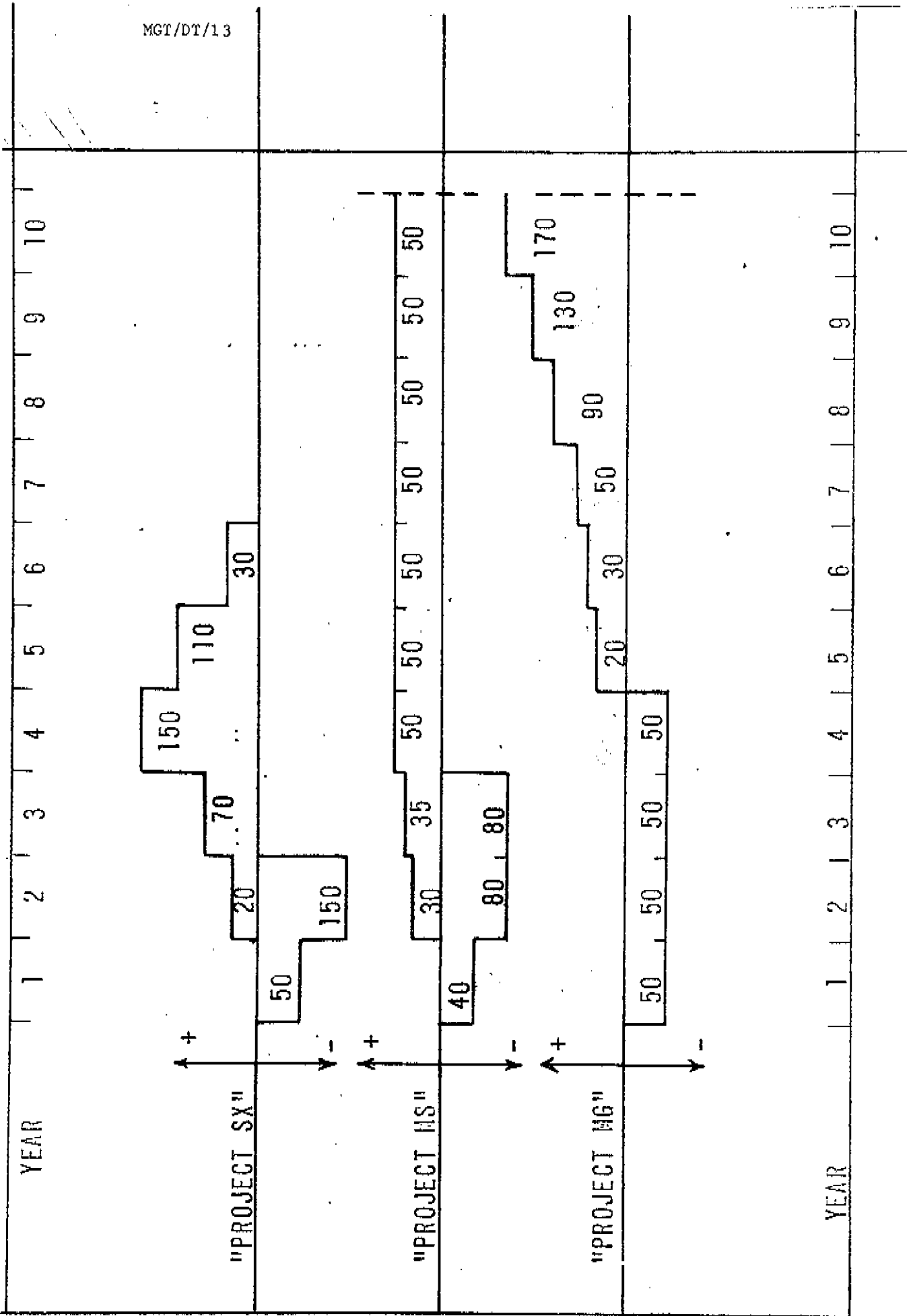
From the previous visual we then have:

$$EMV \text{ at A} = \left( -\$200 \times \frac{1}{20} + 0 \times \frac{19}{20} \right) = -\$10$$

$$EMV \text{ at B} = \left( -\$5 \times \frac{1}{20} + (-\$5) \times \frac{19}{20} \right) = -\$5$$

This reduces our example to one decision fork as shown:





CALCULATION OF NET PRESENT VALUE AND B/C RATIO

YEAR	n	PVF* r = 8%
1		0.93
2		.86
3		.79
4		.74
5		.68
6		.63
7		.58
8		.54
9		.50
10		.46

UNDISCOUNTED AND PRESENT VALUES

PROJECT SX			
BENEFITS	COSTS		
	0%	8%	8%
20	17.2	150	129.0
70	55.3		
150	111.0		
110	74.8		
30	18.9		
380	277.2	200	175.5

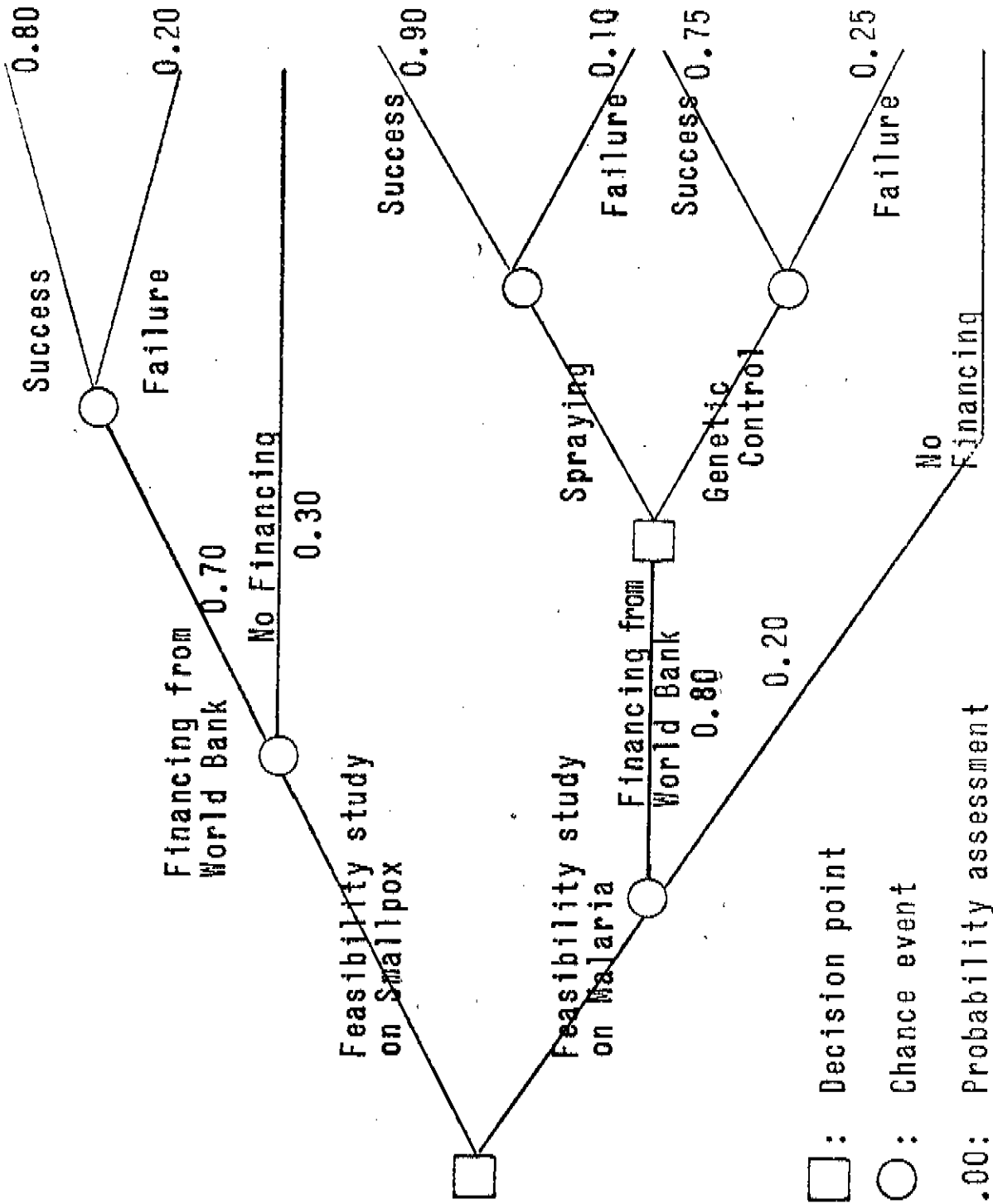
PROJECT MS			
BENEFITS	COSTS		
	0%	8%	8%
30	25.8	40	37.2
35	27.7	80	68.8
50	37.0	80	63.2
50	34.0		
50	31.5		
50	29.0		
50	27.0		
50	25.0		
50	23.0		
415	260.0	200	169.2

PROJECT MG			
BENEFITS	COSTS		
	0%	8%	8%
20	13.6	50	46.5
30	18.9	50	43.0
50	29.0	50	39.5
90	48.6	50	37.0
130	65.0		
170	78.2		
490	253.3	200	166.0

\* PRESENT VALUE FACTOR =

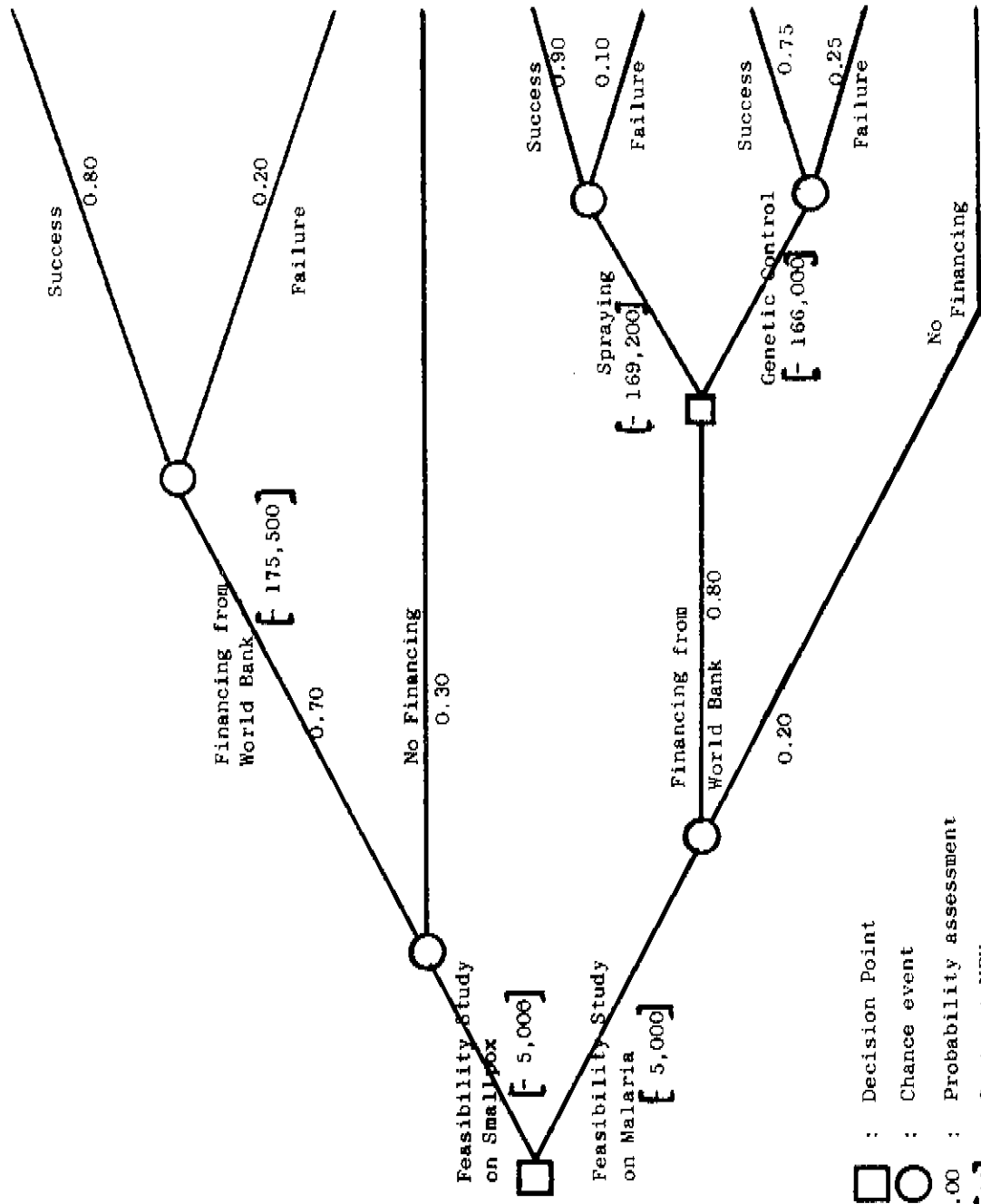
$$= \frac{1}{(1 + r)^n}$$

	NET PRESENT VALUE	BENEFIT/COST RATIO
PROJECT SX	277.2 - 175.5 = 101.7	277.2 / 175.5 = 1.58 (1)
PROJECT MS	260.0 - 169.2 = 90.8	260.0 / 169.2 = 1.54 (2)
PROJECT MG	253.3 - 166.0 = 87.3	253.3 / 166.0 = 1.53 (3)

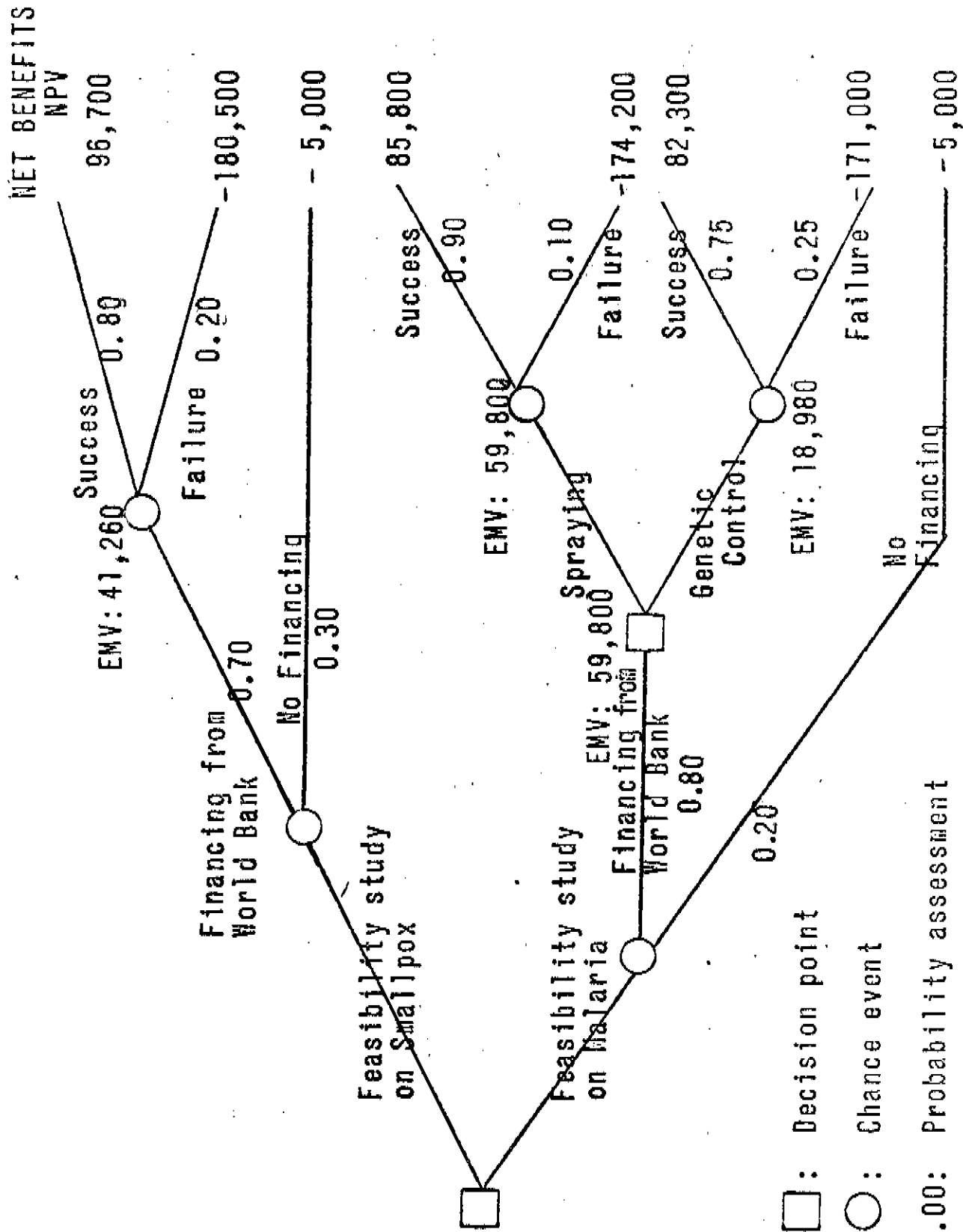


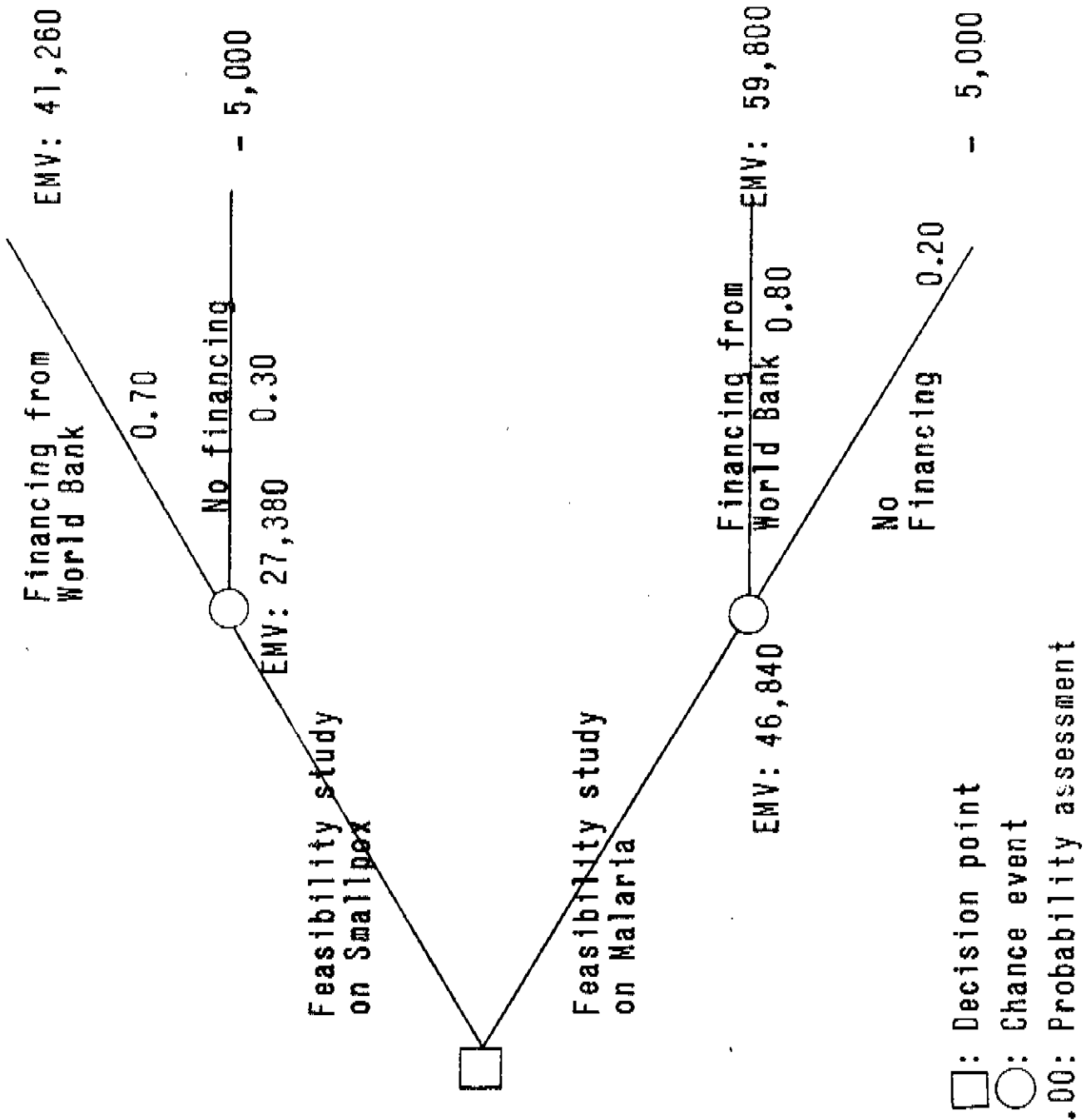
Gross Benefits NPV	Net Benefits NPV
277,200	96,700
0	- 180,500
0	- 5,000
260,000	85,800
0	- 174,200
253,300	82,300
0	- 171,000
0	- 5,000

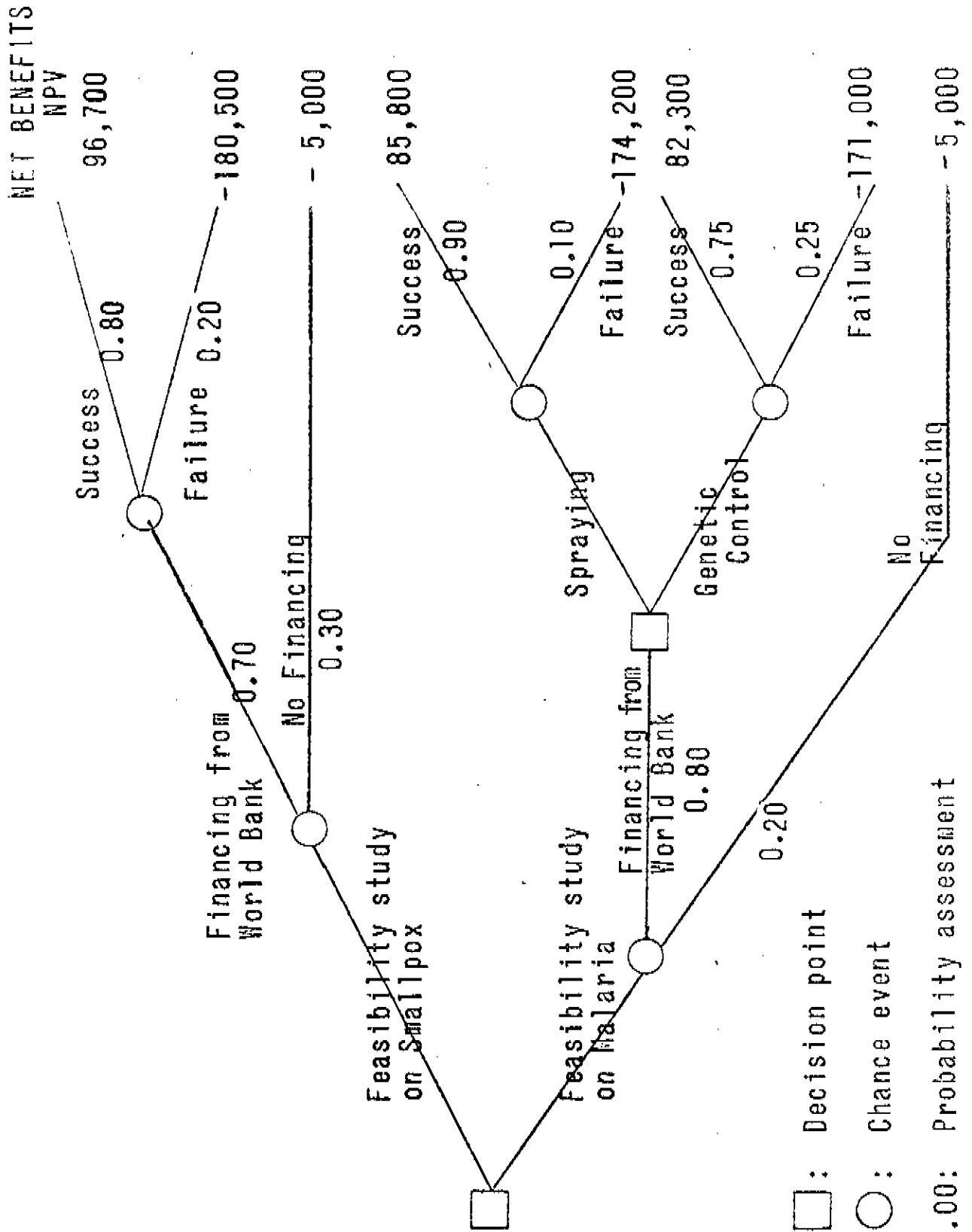
NOTE: Discounted Benefits and Costs from Visual 6



□ : Decision Point  
 ○ : Chance event  
 .00 : Probability assessment  
 [ ] : Costs at NPV







PROJECT	ORDER OF PREFERENCE		
	BENEFITS-COSTS UNDISCOUNTED	B/C ANALYSIS	B/C + DECISION TREES
SMALLPOX	3	1	2
MALARIA, SPRAYING TECHNIQUE	2	2	1
MALARIA, GENETIC CONTROL	1	3	3