

Economics of Information

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1. Cost Vs. Value

BUSINESS success is built on an effective collection and use of information. With data becoming more voluminous daily, it is increasingly important for businessman to know more about the different aspects of acquisition of business information as it is an important input in the Management decision making process.

It is the purpose of this paper to address itself to the problem of Cost and Value of Information. It is suggested that the cost of generating information must not exceed its value. An attempt to design a quantitative cost/benefit model for information with the aid of an illustration follows. This is juxtaposed with a discussion on the structure of management decision and also the various decision models confronted by a manager.

2. Information—Dimensions and Purpose

Information has four dimensions—accuracy, timeliness, relevance and economy. These four dimensions of information can come into conflict. However, a delicate balance has to be struck between them. The information generated should aid management decision making by stimulating response action at the appropriate decisional centre. A decision is defined as teleological or goal seeking, selection of a specific course of action from among a set of alternative courses of action referred to as 'strategies'. Information is defined as data that will probably alter a decision maker's prediction thus changing the decision maker's expectations concerning the future. A manager must make a choice from among alternative strategies. If there is no choice there is no decision. Failure of the manager to make a choice will cause certain malfunctioning in the organisational activity. The manager elects

one strategy over others based on some criteria or combination of criteria of objectives. The selection of a strategy must subserve the organisational objectives. The manager must, in thought and deed, blend his goals with those of the organisation, otherwise the result is incongruent behaviour and disfunctional reactions.

3. Structure of Decisions

A manager has to formalise the decision making process taking cognisance of the following five factors:

- Enumerating a set of mutually exclusive but collectively exhaustive decision alternatives. The alternatives available in any decision problem are referred to as "strategies".
- Enumerating a set of mutually exclusive but collectively exhaustive alternative "states of nature". One and only one of these states will occur at a time, their occurrence, however being beyond the control of the decision maker. The consequences of any strategy alternative will depend on which of these "states" actually does occur.
- A set of probabilities that describe the possibilities of the various states of nature occurring.
- An evaluation criterion for discriminating among the various alternative strategies.
- A set of conditional outcomes expressed in terms of the specified evaluation criterion that describe the payoff associated with a specific action, in a specific state of nature. Each specific configuration of the controllable variable and state of nature results in a unique outcome which is known to the manager.

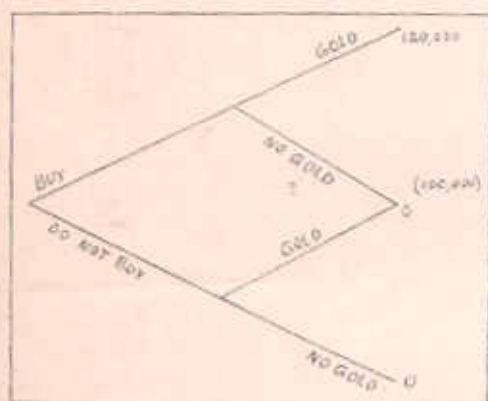
4. Illustration

Assume that a manager is considering investing Rs. 100,000 in a gold mine lease.

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He expects gross proceeds of Rs. 220,000. The net gain will be Rs. 220,000 minus Rs. 100,000 i.e. Rs. 120,000. In conformance with the decision structure the manager enumerates two mutually exclusive but collectively exhaustive alternative courses of action or strategies. He either buys or does not buy the lease. Given the strategies he also predicts that two alternatives will condition his payoffs i.e. the presence or absence of gold. He estimates the probability of the occurrence of each of the states of nature to be 0.5. The sum of the probabilities of occurrence of all states of nature equals one. The alternative strategies and associated probabilities of occurrence of the states of nature are charted below:

CHART 1
(Figures in Rupees)



Selecting the strategy with the largest expected value will result in the most desirable future outcome, *ceteris paribus*. The expected value of a given strategy is defined to be the sum over all possible states of nature, of the conditional payoff (conditioned by a specific state of nature and a specific action) multiplied by the probability of the specific state of nature.

5. Net Expected Value

The Net Expected Value (NEV) with existing information is Rs. 10,000 (Chart 2)

The NEV of the strategy to buy is Rs. 10,000 greater than that of the alternative strategy of not buying. The best strategy, based on the information available is to buy. The outcome however, 0.5 chance of being unfavourable which will result in a loss of Rs. 100,000. An Expected Value of Rs. 10,000 is contingent upon the state of nature of the presence of gold. An opportunity cost of Rs. 120,000 is involved if the strategy not to buy is associated with the state of nature of presence of gold.

These are referred to as conditioned values. The loss occasioned, should the state of nature 'absence of gold' occur, is sizable and this state of nature has a positive (0.5) probability. To overcome, to some extent this contingency, additional information is necessary to make a reliable prediction of the state of nature (presence/absence of gold) so that strategy (buy/do not buy) can be selected with confidence.

CHART 2
ACTION

Event	Probability of Event 1	BUY		DO NOT BUY	
		Conditional Value 2	Expected Value $1 \times 2 = 3$	Conditional Value 4	Expected Value $1 \times 4 = 5$
Gold	0.5	120,000	60,000	0	0
No Gold	0.5	(100,000)	(50,000)	0	0
			10,000		

6. Relevance, Timeliness and Accuracy

It is at this stage that a crucial decision has to be taken by the manager who has to strike a balance between the four dimensions of information. Perfect information is necessary to make reliable prediction of the state of nature (presence/absence of gold). It is intended to discuss briefly the dimensions of relevance, timeliness and accuracy. The main purpose of this paper is however to study the economics of information.

7. Relevance

Information is relevant if its receipt changes the decision and is related to the payoff in some fashion. The value of information depends upon the changes in decision. If relevance is to be measured in terms of utility of information then the criterion should be the use of the information as an input to predict future events and thus measure payoff. If these functions are not involved information is irrelevant. Also the cost of information should be less than the value. If existing information are adequate to perform the functions of prediction of future events and measurement of payoff, additional information is not called for.

8. Timeliness

The timing of the receipt of information influences the quality and quantity of decisions. Information is not available even *ex ante*. It is available event *ex post facto*. The timing for the above reasons influences the payoff. There is always a time lag between the need and actual receipt of information. This is due to the processing time vis-a-vis reporting interval. If intervals are long there is no decision in the intervening period or decision is to be taken with inadequate information. The former relates to the number of decisions that can be made and the latter to the quality of the decisions. Both these adversely influence the payoff. However, continuous reporting creates the problem of cost of reporting which is rather exorbitant.

9. Accuracy

Information has to be accurate. The basis

for prediction of future events is the past and present events. Observations in respect of these must be accurate and free from errors. The actual records should be correctly maintained. Errors are caused because of bias and variability. Bias, defined as the difference between the expected value of estimates yielded by the procedure and the true value, can be eliminated by adjustments in predictions. Variability, defined as the variance i.e. mean squared deviations of the estimates from the true value, is best avoided at source. The question of accuracy, timeliness and relevance has to be resolved to the extent possible at this stage. The issue at hand is, to reiterate, the economics of the additional information. The cost of the information must not exceed the additional value of the same to the firm.

10. Number of Alternatives

It may be stated at the outset that all possible alternatives are not enumerated or considered. A limited range of alternatives are considered. Some of the strategies eliminated might be desirable but the manager may feel that the probability of a satisfactory payoff to be rather small and not to be worth the cost involved in further consideration. How many strategies to present to the manager and the risks of error involved in the elimination of strategies are crucial problems in decision making. There may however be cases where the problem is one of locating an adequate range of alternatives in which case the above concepts do not apply.

The inclusion of more phenomena adds a real cost to the decision process and in constructing the model it should be attempted to balance the predicted value of improved decisions against the predicted cost of improved decision models.

11. E.V.P.I.

With the current information the expected profit of the manager, given the strategy to buy, is the product of the potential gain and the probability of the occurrence of the state of nature of presence of gold on which the gain is contingent i.e. Rs. 60,000. (vide Chart 3).

CHART 3

PROBABILITY OF EVENT AND EXPECTED VALUE

Event	Probability of Event 1	Decision 2	Conditional Value	Expected Value
Gold	[0.5	Buy	120,000	60,000
No Gold	[0.5	Do Not Buy	0	0
				<hr/> 60,000 <hr/>

In the illustration the maximum the manager would be willing to pay for the perfect information would be the difference between the Expected Value with perfect information (60,000) and Expected Value with existing information (10,000) i.e. Rs. 50,000. Rs. 50,000 is the Expected Value of the perfect information. EVPI is also equal to $(100,000 \times 0.5)$

12. Additional Information

The EVPI indicates the maximum amount which a rational manager would pay for perfect information. Assuming that geological testing is necessary to ascertain the potential of the mine the manager is provided with the following additional information.

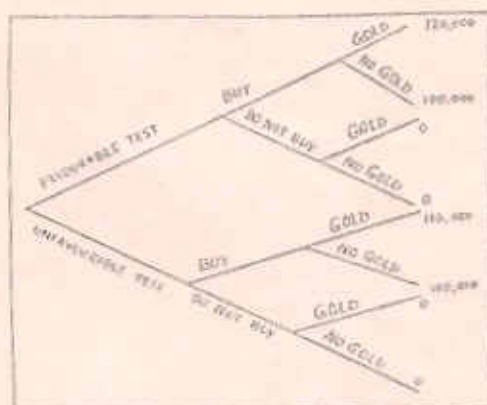
Given the state of nature of the presence of gold the test gives favourable and correct results $3/4$ of the time and gives unfavourable and incorrect results $1/4$ of the time. Given the state of nature of the absence of gold the test gives unfavourable and correct results $2/3$ of the time and favourable but incorrect (falsely favourable) results $1/3$ of the time.

With the receipt of this information the manager is confronted with an altered decision structure (vide Chart 4.)

Additional information means additional predicted data about the states of nature (outcome of Test) influencing the payoff for each combination of strategy and state of nature. The decision models the manager confronts are:

- Model with Certainty
- Model with Risk
- Model with Uncertainty
- Model with Complete Uncertainty

CHART 4
Alternatives with additional Information
(Figures in Rupees)



13. Certainty

Under conditions of certainty the payoff resulting from a given strategy can be precisely quantified. Only one state of nature is assumed to exist. Prediction is assumed to be perfect. The probability of occurrence of a state of nature is assumed to be equal to one. The strategy with the largest payoff is selected. This model is an exception to the models confronted in live business situations.

14. Risk

Risk refers to a situation where the future states of nature are plural and the probabilities of the occurrence of the same can be objectively specified. There exists in this model more than one payoff for each of the strategies prior to the decision. A payoff

exists for each combination of strategy and state of nature. The prediction of the payoffs is assumed to be perfect. Skepticism in respect of the certainty model can be made good by a change to a risk model which permits plural states of nature and payoffs. The predictions of payoff will be more accurate and reliable.

Under this model given the proper strategy alternatives, the payoffs expressed in terms of the value to be optimised, perfect payoff prediction and known probability distribution of the states of nature, an optimal strategy may be selected as the best decision.

15. Uncertainty

Uncertainty refers to a situation where the states of nature are plural but not objectively specified. The decision model most common to live business situations is that involving uncertainty of varying degrees. Ignorance in toto is a rather rare case. The probability of occurrence of the states of nature can be determined in one of the following ways.

- Past objective experience vis-a-vis current investigations based on sampling techniques.
- Best subjective judgement of the decision maker. Past experience observations are not scientifically determined.
- Guess with the aid of subjective impressions.
- Ignorance about the occurrence of the states of nature.

16. Laplace Criterion

Decision under uncertainty involves a range of conditions. The last condition poses a severe threat to scientific decision making. The decision maker does not even have subjective judgments concerning the probability of the occurrence of the states of nature. The decision maker has to resort to rationality, pessimism optimism, regret and surprise.

Rationality assumes that all states of nature are equally likely to occur. This is also referred to as "the criterion of insufficient reason or the Laplace criterion". Pessimism involves the selection of the strategy with the maximum of all minimum payoffs.

Optimism involves the selection of the maximum of the maximums. Regret involves minimisation of the deviance between the actual and expected payoffs. Surprise function involves the combination of outcomes which have varying degrees of likelihood of occurrence in the decision makers' mind. The potential surprise function is combined to arrive at the best strategy.

17. Another Illustration

In the illustration we know that the payoff against a strategy is influenced by the states of nature (gold/no gold) vis-a-vis the test results (favourable/unfavourable). The combined inputs will be used to compute the probability of occurrence of the state of nature (gold/no gold) against each test characteristic and the respective probabilities (favourable/unfavourable). The combined computation will influence the payoff against any strategy.

The revised conditional probabilities are found by weighing the prior probabilities by the appropriate likelihoods of favourable and unfavourable test results.

Chart 5 shows that the probabilities of favourable and unfavourable test results were each 0.5 based upon the prior probability of the occurrence of the state of nature (gold/no gold) vis-a-vis the likelihood of favourable (correct/incorrect) and unfavourable (correct/incorrect) results. The computations in Chart 5 indicate that the probability of finding gold with favourable and unfavourable test results is 0.6 and 0.2 respectively.

Chart 6 shows that the entrepreneur can maximise the expected value by buying the mine if results are favourable and by not buying if the results are unfavourable. Expected payoff from testing and buying only if favourable results are received is computed as follows:

$$(0.5) (32,000) + 0.5(0) = \text{Rs. } 16,000$$

With the test the Expected Value of the best strategy is Rs. 16,000. Without the test Expected Value of the best strategy is only Rs. 10,000 (vide Chart 2). The maximum amount which should be paid for the test is the Incremental Expected Value resulting from the test (Rs. 16,000—Rs. 10,000) i.e. Rs. 6,000.

THE MANAGEMENT ACCOUNTANT

CHART 5

PROBABILITIES OF STATES, GIVEN A FAVOURABLE/UNFAVOURABLE TEST RESULT

Event	Probability of Event 1	Conditional Probability of Favourable/Unfavourable Test 2	Probability of Test Outcome & Event $1 \times 2 = 3$	Probability of Events Given Test Outcome
<i>If the Test is Favourable :</i>				
Gold	0.5	3/4	0.3	$0.3 \div 0.5 = 0.6$
No Gold	0.5	1/3	0.2	$0.2 \div 0.5 = 0.4$
			0.5	1.0
<i>If the Test is Unfavourable :</i>				
Gold	0.5	1/4	0.1	$0.1 \div 0.5 = 0.2$
No Gold	0.5	2/3	0.4	$0.4 \div 0.5 = 0.8$
			0.5	1.0

CHART 6

VALUES OF ALTERNATIVE ACT AFTER TEST RESULTS

Event	Conditional Probability 1	ACT			
		BUY		DO NOT BUY	
		Conditional Value 2	Expected Value $1 \times 2 = 3$	Conditional Value 4	Expected Value $1 \times 4 = 5$
<i>If the Test is Favourable :</i>					
Gold	0.6	120,000	72,000	0	0
No Gold	0.4	(100,000)	(40,000)	0	0
			32,000		0
<i>If the Test is Unfavourable :</i>					
Gold	0.2	120,000	24,000	0	0
No Gold	0.8	(100,000)	(80,000)	0	0

18. Conclusion

The decision regarding the quantum of information to be generated is rather crucial. There is no scientific principle governing this decision. To quote Trueblood and Maffei:

"... there are today no generally accepted criteria for the design of an integrated information system for a firm—for deciding what information is needed, how frequently the information is required, how accurate it needs to be, and how the information is to be originated and transmitted. There is today no structural method of viewing many of the financial, and nonfinancial, decisions of the firm."

A theory of the cost and value of information is needed. We need to know quantitatively what price is being paid by deviating from a "best" course of action and weigh this against the cost of getting better information.

We require a model that will adequately predict the effects of varying the control variable or action configuration. The inputs in the decision model must be capable of adequately predicting the real system's dynamics, and must be procured at a cost not greater than the benefits.

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