

ANALYSIS OF COST-BENEFIT EVALUATION MODELS BY SENSITIVITY AND RISK MANAGEMENT FOR MONITORING AND CONTROLLING OF A PROJECT LIFE CYCLE

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ABSTRACT

The financial and economic benefit-cost models of projects are based on forecasts of quantifiable variables such as product availability, demand, costs and benefits. The values of these variables are estimated due to the probable forecasts which stand for a long period of time. The mathematical models and values of these variables for the expected outcome results are influenced by a great number of sensitivity and risk indicators, and the parameters may differ considerably from the forecasted values, depending on future developments. As a result, cost-benefit evaluation develops these models for monitoring and controlling of scope, time, cost and quality of a project.

Keywords: Risk, Sensitivity, Cost, Benefit, Project.

INTRODUCTION

The project performance indicators can be chosen with a preliminary set of studies: large numerical variables (investment cost, project demand), essential variables (population growth and revenue earning), early project cost (investment cost, actual fixed operating costs), economic changes

and real income. The viability of projects is evaluated based on a comparison of its PERT, CPM, IRR, NPV, SV, SI, BCR, PBP, EOQ, BEP, EMV, ROI, Standard deviations and Variance, Contract and WACC to the financial or economic cost of capital. These key indicators have useful effects to consider the viability of the project.

Sensitivity and risk management can be useful for a lot of purposes. It performs the testing the robustness of the results of a model or system in the presence of uncertainty, increases understanding of the relationships between input and output variables in a system or model, reduces uncertainty reduction with identifying model inputs that cause significant uncertainty in the output and should therefore be the focus of attention if the robustness is to be increased for further research. It searches for errors in the model (by encountering unexpected relationships between inputs and outputs), simplifies models – fixing model inputs that have no effect on the output, or identifies and removes redundant parts of the model structure, enhances communication from modelers to decision makers (e.g. by making recommendations more credible, understandable, compelling or persuasive), finds regions in the space of input factors for which the model output is either maximum or minimum or meets some optimum criterion and Monte Carlo filtering [3]. It is a study of uncertainty in the output of a mathematical model. A management tool is used to determine how different values of an independent variable will assess

a particular dependent variable under a given set of parameters [4]. During multiple internal rates of return, the IRR approach can still be interpreted in a way that is consistent with the present value approach provided that the underlying investment stream is correctly identified as net investment or net borrowing. If a project has multiple IRRs it may be more convenient to compute the IRR of the project with the benefits reinvested [15]. Official surveys indicate that project managers and executives prefer IRR over NPV [16]. Project risk is an uncertain event or condition and it has a positive or negative effect on one or more project such as scope, schedule, cost and quality. Positive and negative risks are commonly referred to as opportunities and threats [17].

NPV:

It means **Net present value** which is the present value of net cash inflows generated by project including salvage value, if any, less the initial investment on the project. It is one of the most reliable measures used in capital budgeting because it accounts for time value of money by using discounted cash inflows. It means **net present worth**

which is defined as the sum of the present values of incoming and outgoing cash flows over a period of time [13]. For calculating NPV, a target rate of return is set which is used to discount the net cash inflows from a project. Net cash inflow equals total cash inflow during a period less the expenses directly incurred on generating the cash inflow. *For even cash flows, NPV =*

$$RX \frac{1-(1+i)^n}{i} - \text{Initial Investment}$$

R= Net cash inflow expected to be received each period, i= Rate of return per period, n= Number of periods in which the project is expected to be operated and generated cash inflows.

For uneven cash flows, NPV= Present value of cash inflow-Present value of cash out flow

$$NPV = \frac{R1}{\{1+i\}} + \frac{R2}{\{1+i\}^2} + \frac{R3}{\{1+i\}^3} + \dots - \text{Initial Investment}$$

i= Target rate of return each period, R1= Net cash inflow during the first period, R2= Net cash inflow during the second period, R3= Net cash inflow during the third period and so on.....

NPV will be positive or zero and reject the project having negative NPV. For comparing two or more exclusive projects having positive NPVs, accept the one with highest NPV.

IRR:

Internal rate of return is a discounted cash flow rate of return used in capital budgeting to measure and compare the profitability of investments [14].

$$0 = \frac{CF1}{\{1+r\}} + \frac{CF2}{\{1+r\}^2} + \frac{CF3}{\{1+r\}^3} + \dots - \text{Initial Investment}$$

Where, CF= Cash flows per period and r= Internal Rate of

Return. Internal Rate of Return, IRR =

$$\left(\frac{FV}{PV}\right)^{\frac{1}{N}} - 1 \text{ \& Project Cost} = \sum_{n=0}^P = \frac{In}{\{1+IRR\}^n}$$

In= Project Net income in n years, N= Number of periods over in which the income occurs

CPM:

Critical Path Method was developed to schedule the start up and shut down of major plant. CPM uses time-cost-trade-off. Four

activities were considered: normal time, normal cost, crash time, crash cost.

Duration compression,

Crashcostperday =

$$\frac{\text{Budget} - \text{Crash Budget}}{\text{actual duration} - \text{crash duration}}$$

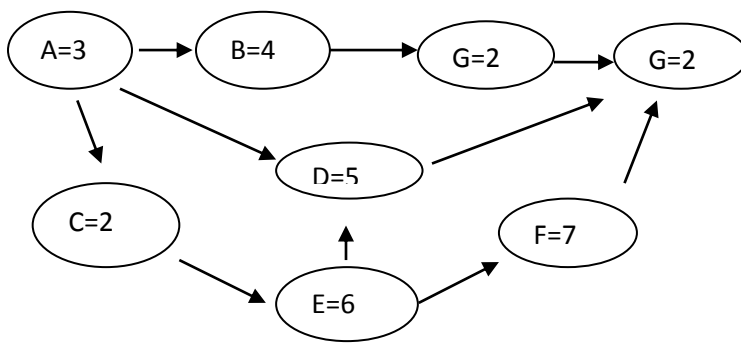


Figure 1: CPM for project scheduling

Critical path analysis is a procedure to calculate the critical path in a schedule or network diagram and to calculate the float [Figure 1]. Most of the project management and planning software will calculate this automatically for the user, but it is important to understand how this is done and so the plan can be clearly communicated and reviewed by all stakeholders.

To calculate the critical path:

Forward pass: Calculates the Early Start and Late Start dates for activities.

Backward pass: Calculates the Early Finish and Late Finish dates for activities.

Early Start: The earliest an activity can start explained the logic and constraints of the path.

Late Start: The latest activity can start explained the logic and constraints without delaying the project.

Early Finish: The earliest an activity can finish explained the logic and constraints of the path.

Late Finish: The latest activity can finish explained the logic and constraints without delaying the project.

BCR:

This is a ratio of benefits to cost by monetary value of a project or a proposal. It takes into account the amount of monetary gain realized by performing a project versus the amount it costs to execute the project. The higher the BCR the better the investment and project viability is more.

It is designed to inform the practical decision-making of enterprise managers and investors focusing on optimizing their social and environmental impacts. We have,

$$BCR = \frac{Benefits}{Costs}$$

WACC:

A mathematical calculation of a project's cost of capital in which each category of capital is proportionately weighted. For a project government, donor portions and borrowers are identified and for a company sources common stock, preferred stock, bonds and any other long-term debt - are the factors of WACC calculation. For a project: WACC is the average of the costs of components of financing, each of which is weighted by its respective use in terms of applications. By taking a weighted average, we can see how much performance the project has been obtained for every dollar it finances.

$$WACC = (K_e \cdot W_e) + (K_p \cdot W_p) + (K_d[1 - t]W_d)$$

Where, WACC= Weighted Average Cost of Capital, K_e = Cost of common equity capital, W_e = Percentage of common equity in the capital structure, at market level, K_p = Cost of preferred equity, W_p = Percentage of preferred equity in the capital structure, at market level, K_d = Cost of debit (pre-tax), t =Tax, W_d = Percentage of debit in the capital structure, at market level.

We have another concept: $WACC = \frac{E}{D+E}(R_e) + \frac{D}{D+E}(R_d)(1 - t)$

E=Market value of Equity, D= Market value of Debit, r_e = Cost of equity, r_d = Cost of debit

t =Corporate tax rate

For a company: The WACC equation is the cost of each capital component multiplied by its proportional weight and then summing:

$$WACC = \frac{E}{V} * R_e + \frac{D}{V} * R_d * (1 - T_c)$$

Where, R_e = cost of equity R_d = cost of debt
E = market value of the company's equity
D = market value of the company's debt
V = E + D
E/V = percentage of financing that is equity
D/V = percentage of financing that is debt
 T_c = corporate tax rate.

Table 1: Weighted Average Cost of Capital

Sample Calculation of Weighted Average Cost of Capital				
Classification	Weight	Normal cost	After Tax (tax 40%)	WACC
ADB Loan	40%	6.7%	4.02%	Nominal at 6.55%
Commercial Loan	20%	12%	7.2%	
Grant	5%	00%	00%	
Equity Participation	35%	10%	10%	Inflation rate
Total	10			

	0%			4.00 % WA CC 2.45 %
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$$WACC(real) = \frac{1 + WACC\ nominal}{1 + inflation} - 1$$

$$WACC(real) = \frac{1 + .0655}{1 + .04} - 1$$

$$WACC(real) = 2.45\%$$

SV: Sensitivity analysis is a sampling based approach. It is performed by running the model a number of times [1]. This technique is useful for specific boundaries that will depend on one or more input variables, such as the effect that changes in rate of return will have on the amount of total investment. It limits the percentage change in a variable or combination of variables to reduce the NPV to zero (0) and the percentage change in a variable or combination of variables to reduce the IRR to the cut-off-rate (=discount rate) [9].

Considering Net Present Value:

$$SV = \frac{(100 \times NPVb)}{NPVb - NPV1} \times \frac{(Xb - X1)}{Xb}$$

Where, Xb= Value of variable in the base case, X1= Value of the variable in the sensitivity test, NPVb= Value of NPV in the base year, NPV1= Value of the variable in the sensitivity test

Considering Internal Rate of Return:

$$SV = \frac{(100 \times (IRRb - d))}{IRRb - IRR1} \times \frac{(Xb - X1)}{Xb}$$

Where, IRRb= Value of IRR in the base case, IRR1= Value of the variable in the sensitivity test, d= Discount Rate

SI: SI is a cause-effect analysis technique which can be used to support the filtering of unsolicited data to reduce the communication and computational capabilities of a standard supervisory control and data management system [2]. It compares percentage change in NPV with percentage change in a variable or combination of variables and the percentage change in IRR above the cut-off rate with percentage change in a variable or combination of variables [9].

Considering Net Present Value: $SI = \frac{(NPVb - NPV1)/NPVb}{(Xb - X1)/Xb}$

Where, Xb= Value of variable in the base case, X1= Value of the variable in the sensitivity test, NPVb= Value of NPV in the base year, NPV1= Value of the variable in the sensitivity test

Considering Internal Rate of Return: $SI = \frac{(IRRb - IRR1)/(IRRb - d)}{(Xb - X1)/Xb}$

Where, IRRb= Value of IRR in the base case, IRR1= Value of the variable in the sensitivity test, d= Discount Rate

Case Study:

In the base case, the ENPV is 126 and the EIRR is 13.7%. The sensitivity of the base case ENPV has been analyzed for (adverse) change in several key variables, as follows:

i) An increase in investment cost by 20%, ii) A decrease in economic benefits by 20%, iii) An increase in costs of operation and maintenance by 20% iv) A delay in the period of construction, causing a delay in revenue generation by one year.

Table 1: Sensitivity Analysis

Item	Change	NPV	IRR	SI (NPV)	SV (NPV)
Base Case		126	13.7		
Investment	+20%	-211	9.6	13.3	7.5%
Benefits	-20%	-294	7.8	16.6	6%
O & M Costs	+20%	68	12.9	2.3	43.4%
Construction delays	One year	-99	10.8	NPV 178% lower	
SI= Sensitivity Indicator, SV= Switching Value					

In the case of an increase in investment costs of 20%, the higher the SI, the more sensitive the NPV. The lower the SV, the more sensitive the NPV is to change in the variable concerned and the higher the risk with the project.

PBP:

Payback period in capital budgeting explains the period of time required to recoup the funds expended in an investment, or to reach the break-even point. It intuitively measures how long something takes to "pay for itself." and shorter payback periods are preferable to longer payback periods. It is popular due to its ease of use despite the recognized limitations

Payback Period = Amount to be initially invested / Estimated Annual Net Cash Inflow [10].

$$\text{Payback Period} = \text{Last year with a negative NCF} + \frac{\text{Absolute value of NCF in that year}}{\text{Total cash flow in the following year}}$$

Payback period does not specify any required comparison to other investments or not to recommend making an investment.

PERT:

Program Evaluation and Review technique (PERT) is a statistical tool, used in project management, which was designed to analyze and represent the tasks involved in completing a given project.

Expected completion time (duration)

$$T_E = (P + 4M + O) / 6$$

P= Pessimistic Time, M= Most likely time, O= Optimistic Time

Standard deviations (σ) and Variance:

Standard deviation is the square root of the variance. It is a measure that is used to quantify the amount of variation as well as dispersion of a set of data values. [11]. It is an average absolute deviation [12]. The standard deviation formula is similar to the variance formula. It is given by:

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2}$$

σ = standard

deviation, x_i = each value of dataset, \bar{x} (with a bar over it) = the arithmetic mean of the data, N = the total number of data points, $\sum (x_i - \text{mean})^2$ = The sum of $(x_i - \text{mean})^2$ for all datapoints. For estimating, Standard Deviation, $\sigma = (\text{Pessimistic} - \text{Optimistic})/6$

In theory of statistics, **variance** measures how far a set of numbers is spread out and a variance of zero indicates that all the values are identical. $\text{Var}(X) = \sigma^2$

EOQ:

Economic order quantity (EOQ) optimizes the total inventory holding costs and ordering costs to obtain a production schedule. This order quantity was developed as **Wilson EOQ Model** [7], **Wilson Formula** or **Andler Formula** [8]. It is

useful for making project procurement decisions at the final stage of a project.

Assumptions of EOQ model: Demand rate is known & constant, Shortages are **not** allowed, and Delivery lead times are **0**.

Total Cost/Cycle = Production Cost or Setup Cost/Cycle + Order Cost/Cycle + Holding Cost/Cycle.

$$TC = PD + \frac{DK}{Q} + \frac{hQ}{2}$$

To optimization of Q: $0 = -\frac{DK}{Q^2} + \frac{h}{2}$; Now we have optimal order quantity: $Q = \sqrt{2DK/h}$

Where, P = purchase price, unit production cost, Q = order quantity, Q^* = optimal order quantity, D = annual demand quantity, K = fixed cost per order or setup cost (*not* the cost of goods but typically cost of ordering and shipping and handling), h = annual holding cost per unit, also known as carrying cost or storage cost (capital cost, warehouse space, refrigeration, insurance, etc. usually not related to the unit production cost)

BEP:

The **break-even point (BEP)** in project management is the point at which total cost and total return are equal [5]: There is no net loss or gain, and one has "broken even." A profit or a loss has not been made but

opportunity costs have been "paid", and capital has received the risk-adjusted, expected return. Finally, all costs that have to be paid are paid by the company but the profit is equal to zero [6].

$$TR=TC; \quad PX=TFC+VX; PX-VX=TFC;$$

$$So, BEP, (X) = \frac{TFC}{\{P-V\}}$$

TFC=Fixed Cost, P=Selling Price, V=Variable Cost

ROI:

ROI is an indicator used to measure the financial gain/loss (or "value") of a project in relation to its cost. Typically, it is used in determining whether a project will yield a positive payback and have value for the business. It quantifies project value, builds stakeholder support, uncovers additional benefits, lead to project prioritization [20]. *Return on Investment, ROI =*

$$\frac{\text{Gain} - \text{Cost of Investment}}{\text{Cost of the investment}} * 100\%$$

ROI has quantifiable improvements to capture more billable time, decrease in non-strategic project acceptance, improve allocation of resources, increase budget accuracy, reduce on cost overruns, reduce in project failure rate and reduce in project delivery time. It has possible benefits to increase chance of winning bids, decrease

time required to create reports, decrease time spent updating statuses, improve handling of change requests, increase accuracy in expense reporting, improve morale, increase accountability and submit more-accurate expense reporting. It is impossible to determine the actual ROI, but the numbers and considerations above can help to create a more-accurate estimated ROI projection. Numbers can be adjusted based on the actual profit margin of a company, which may be above or below the average [19].

EMV:

The Estimated Monetary Value (EMV) formula is probability multiplied by impact. If that sounds like a simple one step calculation but it's only weakness is in having accurate impact and risk values. In addition, it is crucial since it is used in risk management. As the project manager it's his responsibility to determine and constantly recheck those values. Under the assumption that those values are accurate this formula is used to select options among courses of action and quantitatively prioritize a risk within a set of known risks. This is calculated in dollars because we are using

probability to determine value, not vice versa. Usually the opportunities will be expressed as positive values and threats as negative values.

EMV= (Probability) x (Impact); i.e.

$$EMV = \sum_{i=0}^n CFi(1 + R)^{wi}$$

Now a day, another management technique is used to calculate complex Expected Monetary Value calculation by conducting Decision Tree Analysis. This analysis helps while making complex project risk management decisions [18].

CONTRACT

Contract has the potentiality to create and control many risks for cost-benefit models. A contract is an agreement having a lawful object entered into voluntarily by two or more competent parties, each of whom intends to observe one or more legal bindings between them. The components of a contract are "offer" and "acceptance" by "competent persons" having legal capacity who can exchange "consideration" to create "mutuality of obligation" [23]. Project management contracts are legal agreements between project manager and his/ her customers. Project manager selects which

contract best suits the project and negotiates the terms. The contract spells out the duties of each party while the contract is in force. Project management contracts are used throughout the construction industry and for engineering projects.

- a) Fixed Price Contract: It is a lump-sum payment or straight forward contract with cash payment. Incentive Fee= (Target cost- Actual cost) x % of cost saving

Total fee seller received= Target fee + Incentive fee

Point of Total Assumption,

PTA

$$= \frac{\text{Ceiling price} - (\text{Target cost} + \text{Target fee})}{\% \text{ of buyer}}$$

+ Target Fee

- b) Fixed price plus incentive contract: Incentive= (Target price-project cost-profit)x% of seller.

Final price= Actual cost+ profit+ Incentive.

- c) Fixed price incentive fee (FPIF) contract: Profit=Target Cost- Actual Cost

Incentive=% of incentive x Profit

Profit Amount=Target profit + Incentive

Total Price=Actual Cost + Profit

Total price \leq Maximum price in the ceiling

d) Cost-Plus-Incentive-Fee (CPIF): Total
Incentive fee=% of incentive fee x
Targeted amount

Share of cost savings=% of seller cost
savings x (targeted cost –actual cost)

Payout or cost of the total contract= actual
cost + Incentive fee + share of cost savings

e) Cost-plus incentive adjustment contract:
Seller fee=target fee + fee adjustment
seller fee.

Fee adjustment for seller= % of seller
portion x under run or over run.

f) Time and Material Contract: Contract
Value= Actual effort * Agreed rate [17].

g) Unit rate Contract: Total labor cost = No
of labor hour x labor rate.

Numerical Analysis with graphical presentations:

The purpose of uncertainty and risk analysis is to estimate the probability that the project economic return will bellow the opportunity cost of capital.

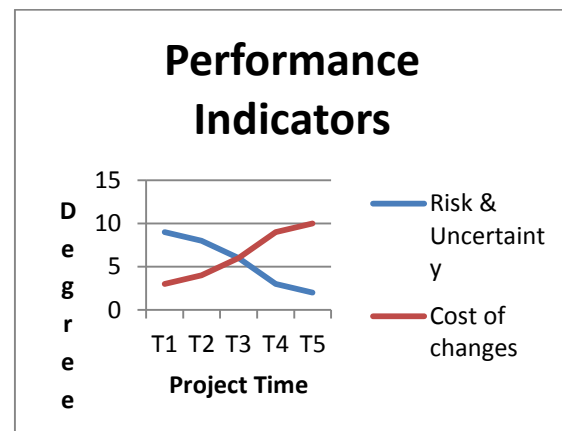


Figure 2: Risk and cost of changes with project schedule

Cost of change is an indicator to measure the financial return on investment of an income generation project and is used to make the investment decision [Figure 2]. There are two kinds of distinct activities perceived by the project investment decisions. One is finance-oriented activities which relate directly to the movement of investment funds between the project entity and the investors such as the shareholder and the lender [21]. The other is operation-oriented activities which relate to business transactions between the project entity and the related parties such as the supplier/contractor, the government and the consumer/user [22]. Risk and uncertainty indicators reduce the productivity of knowledge of workers, decrease cost-effectiveness, profitability, goodwill,

service, quality, reputation, brand value, and earnings quality.

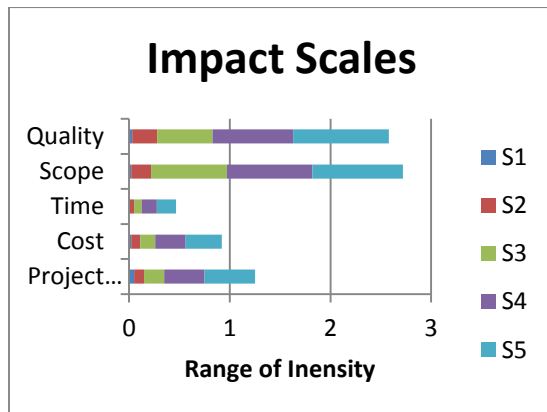


Figure 3: Project objectives with its impacts

Project stakeholders are: the project entity (such as a joint venture company), the shareholder, the lender, the supplier/contractor, the government and the consumer/user, and cash flows. The project entity deals with all the cash transactions, while the shareholder invests equity capital and receives dividends; the lender extends a loan and receives. Project objectives have a significant impact on cost, time, scope and quality [Figure 3].

CONCLUSION

Sensitivity and risk analysis develop a lot of techniques for investigating the impact of changes in project variables on the most probable outcomes and its base case. The

aspects of project feasibility require sensitivity and risk analysis for demand analysis, least cost analysis, sustainability analysis and distribution analysis. Sensitivity indicators can help to identify the adverse changes which influence project cost and benefit streams, assess project decision, and mitigate possible actions. A risk analysis requires more information than for sensitivity analysis. It is the study of how the variation of the output of a model can be described, qualitatively or quantitatively to different sources of variation in the input of model. It is a technique for systematically changing parameters in a model to determine the effects of such changes. It is useful for i) the development of recommendations for decision makers, ii) enhancing communication from modelers to decision makers, iii) increased understanding or quantification of the system, iv) model development.

RECOMMENDATION

Sensitivity and risk analysis should be carried out in a systematic way to evaluate cost-benefit models. The following recommendations are suggested:

- i) identify key indicators to which the project decision might be viable
- ii) calculate the effect of changes on the base-case IRR, NPV, SV, SI
- iii) evaluate possible combinations of indicators in adverse situations
- iv) Establish a balanced scale and direction of likely changes of indicators to obtain a viable project.

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