

Financial Engineering and Project Risk Management: Imperatives for Professional Quantity Surveyors

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Abstract

Financial Engineering is synonymous with designing the appropriate financing strategies for a project, taking into consideration cost and impact on project risk and cost management of the project. Project risk management is a formal process that systematically identifies, analyzes and responds to risk throughout a projects lifecycle. In most developing economies, quantity surveyors shy away from their role of financial engineering, cost engineering and management of process plant projects for lack of familiarity with these concepts and methods. Thus the primary aim of this article is to provide quantity surveyors with an understanding of the tools and skills needed to meet their expanded challenge of financial engineering and risk management which are essential elements of project control and cost management in process plant projects. The paper presents an integrated framework for financing and managing risks of mega projects.

Keywords: Financial Engineering, project risks, systematic management, integrated framework.

1. Introduction

Finance is the application of a series of economic principles to maximize the wealth or overall value of a firm (business) i.e. to make the highest possible profits at the least risk (Nikbakht, 1990).

Finance has developed many sophisticated approaches to provide financial managers with tools for solving difficult business problems: managing working capital, maintaining financial records, interpreting balance sheets/income statements.

Currently finance has extended its practice horizon to budgeting scarce resources effectively and to design, source and invest funds in the assets or projects that yield the best risk/return trade-offs often termed “financial engineering”.

Financial records analysis provides a means of flexible judgment for making the right investment decisions at the right and most advantageous time.

Financial managers have responsibility to find the best and least expensive sources of funds and to invest these funds into the best and most efficient mix of assets. In doing this, they seek/find the mix of available resources that will achieve the highest return at the least risk.

Financial managers/cost engineers consider the effects of changing supply, demand, and price conditions and other general fiscal/monetary policy directions (i.e. micro/macro economic factors) in designing funding and operating conditions of their projects, specifically in determining when it is best to issue stock, bonds, or other financial instruments.

1.1 Micro Economic Factors

In micro project consideration, the sale of products (of a project) at a profit depends heavily on how well the managers are able to analyze and interpret supply and demand conditions to control production costs and hold costs down so that prices can be set at competitive level. For instance, to obtain the best machinery, material, and labour factors at economic costs to squeeze out the biggest possible profit under given supply conditions. The choice of one machine over another involves considering the risks associated with each machine. Maintaining a low-cost operation will enable the firm to charge competitive price for its product and maintain its market share while still obtaining a reasonable return. On the revenue side, understanding and promptly responding to changes in demand allows the proactive cost engineer/financial manager take full advantage of market conditions – when to raise and/or lower prices or apply liberal credit terms to increase sales and reduce finished good inventories.

1.2 Macro Economic Factors

Cost engineer and financial manager must develop a flexible strategy to deal with internal/external factors that could result in major shifts in demographics, changes in legislation or tax laws and new technological breakthroughs. They must engage in financial planning so that they can be armed with different alternatives under different economic conditions.

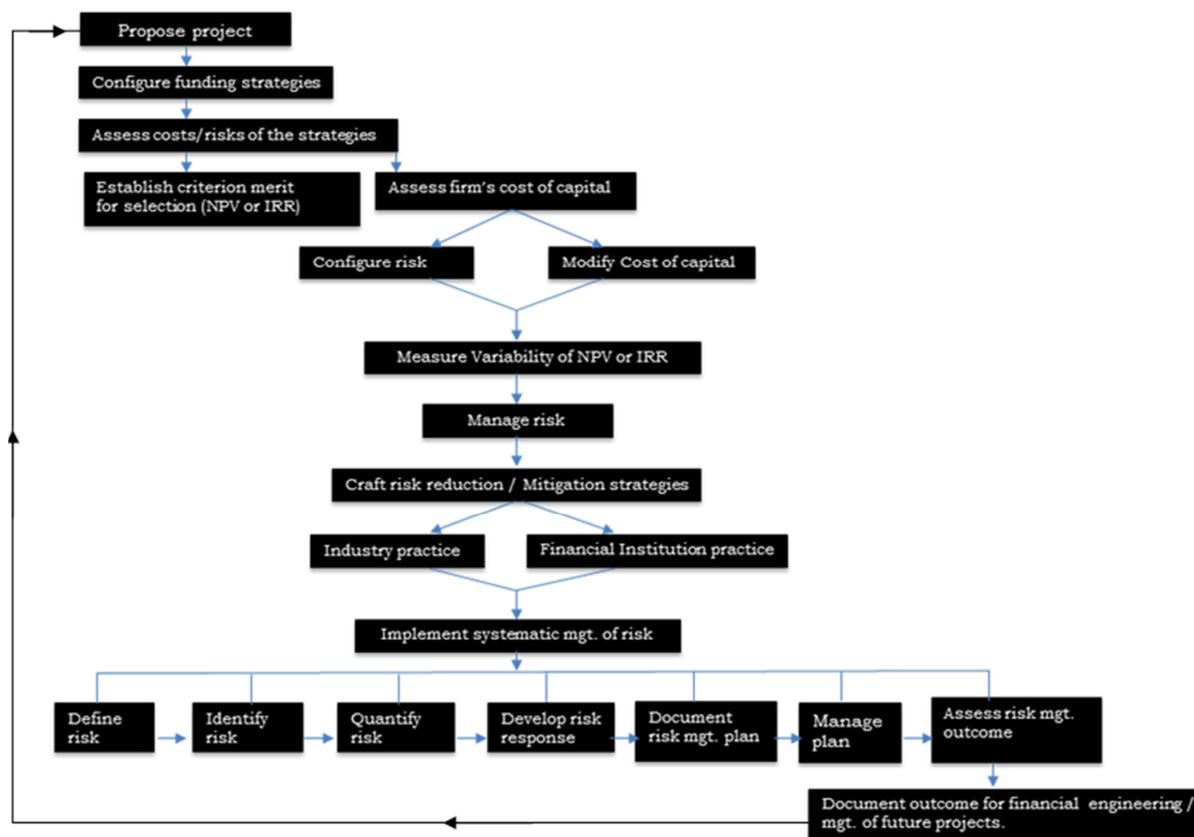


Figure 1: Integrated Framework for Financial Engineering and project Risk Mgt.

Source: Ajator's Research 2013

1. Type/sources of funding

The amount of investible fund in the market at anytime can be grouped into two main kinds namely: equity and loan. Their respective proportions depend on the general health of the economy. In a strong economy where inflation is low, interest rate will be low relative to yields and more funds will flow into equity (i.e. investors put their money in equity which pays dividends out of increased business profits).

Conversely, in a weak economy where inflation is high, businesses are making losses and cannot pay dividends and fund owners will put their money in the banks instead of equity. Where deposit interest rates are attractive, loan able funds will increase and vice versa.

Short-term credit – is made out of very costly and sensitive funds which depositors may request back in a short while. The tenor may not exceed 90 days.

Medium term credit – is extended out of moderately charged and less sensitive funds with tenors 2 – 5 years.

Long term credit – is given out of virtually dormant capital like life savings deposits, pension funds etc, less seldom demanded by their depositors, thereby enabling their commitment into less risky, growth-oriented ventures at cheapest interest cost (it is the cheapest credit).

Equity funds – are that part of the “free money” not saved in banks, etc, but directly committed as of choice to investment. Obviously, the total volume of funds channeled this way will depend on the comparative yield advantage as discerned by investors and emanate from purchase of stocks etc. Equity capital is costly and is not protected by any undertaking of any sort except by the integrity and skills of the person utilizing such fund. Rarely are business/investment financed solely from one source equity or loan.

Improved financial engineering constantly seeks to achieve an optimal combination of various kinds and sources of finance that minimizes cost of capital and maximizes return on capital employed through carefully measured combination of various types of debt and equity.

Investment in industrial and construction outputs usually require long period to pay back. It is plagued by cost/time over-runs, modifications/change orders and high finance cost. These peculiarities make it unattractive to obtain money from finance companies whose funds are short-term and expensive.

2. Fund sources

(Ajator; 1991, 1993) present fund sources to include Commercial banks, merchant banks, Development banks, Industrial development banks; Federal Mortgage bank, National Housing fund, Primary Mortgage Institutions, National Development Finance companies (NIDB, NBCI, NACB etc)

Private finance sources i.e. funds in private hands to be aggregated for investment in infrastructure debt instruments if these are properly structured with adequate returns.

Foreign private sector funds (e.g. foreign direct investments on industrial plants in Nigeria). Local/Foreign Syndicated Funds. Multilateral finance sources—international monetary fund/world bank and its affiliates, International bank for reconstruction and development IBRD, International Finance Corporation (IFC), International Development Association (IDA) etc other regional funding sources: African development bank (ADB) European/Asian Development Funds; Organization for economic Co-operation and Development (OECD) Funds, Economic Commission Funds, Millennium Development Goals (MDGs) Funds, Bilateral/Joint Venture Fundings, export credit, letters of credit; purchasers/suppliers credit etc. Project funds must be accurately, consistently, efficiently and effectively managed, adhering to the International best practice of sound financial management.

The funds must be efficiently managed to meet financial requirements of your organization and also those of the International funding body, to avert adverse consequences of project termination, reduced total contract payment/fund requested back, and its problems at project process/completion stages. Avert prejudiced future collaboration between partners and reputational risk of financial engineer and creditors. Special skill and good financial engineering practice are required to be able to successfully deliver the project. International grant funds for project require prudent “grant-agreement” negotiations with sound financial/project reporting and auditing. Hence you must demonstrate expertise in preparing financial reports following rules/regulations of fund suppliers to avoid financial mismanagement.

3. Risks

Chapman and Corper (1983), define risk as – “exposure to the possibility of economic or financial loss or gains, physical damage, or injury, or delay as a consequence of the uncertainty associated with pursuing a course of action”

Risk management task may be undertaken in three steps:-

- Risk identification
- Risk analysis and
- Risk responses

Rao, Tummala and Y.H. Leuna (1999) developed a methodology for managing the cost risk of a transmission line project that looks at risk identification, measurement, assessment, evaluation, risk control and monitoring.

Perry and Hayes (1985) present a checklist of risk that may occur throughout the lifespan of any project.

Dey (1999) used the Delphi technique for identification of risk factors and Dey (2001) used Monte Carlo simulation for analyzing project risk of petroleum pipelines.

Conventionally, risk analysis is performed at the overall project level. The risk analysis should show the effects of the risk factors on the project performance in terms of time, cost, and quality goals. Although risk analysis at the project level may be sufficient for a small project from the investment-decision and feasibility-study point of view, the technique has its limitations for large projects. Corper et al (1985) suggested that, in the risk-engineering approach, systematic risk evaluation could be performed by subdividing a project into its major elements, and analyzing the risk and uncertainty associated with each in detail.

Dey (2002) crafted a risk management flow chart that assesses/manages risk of project work packages (see figure 2 below)

Moreover, the severity of risk pertaining to a project varies from activity to activity. Some activities are more responsive to a specific risk than others. To risk-analyze a project, the level of activity for which risks are to be analyzed has to first be determined.

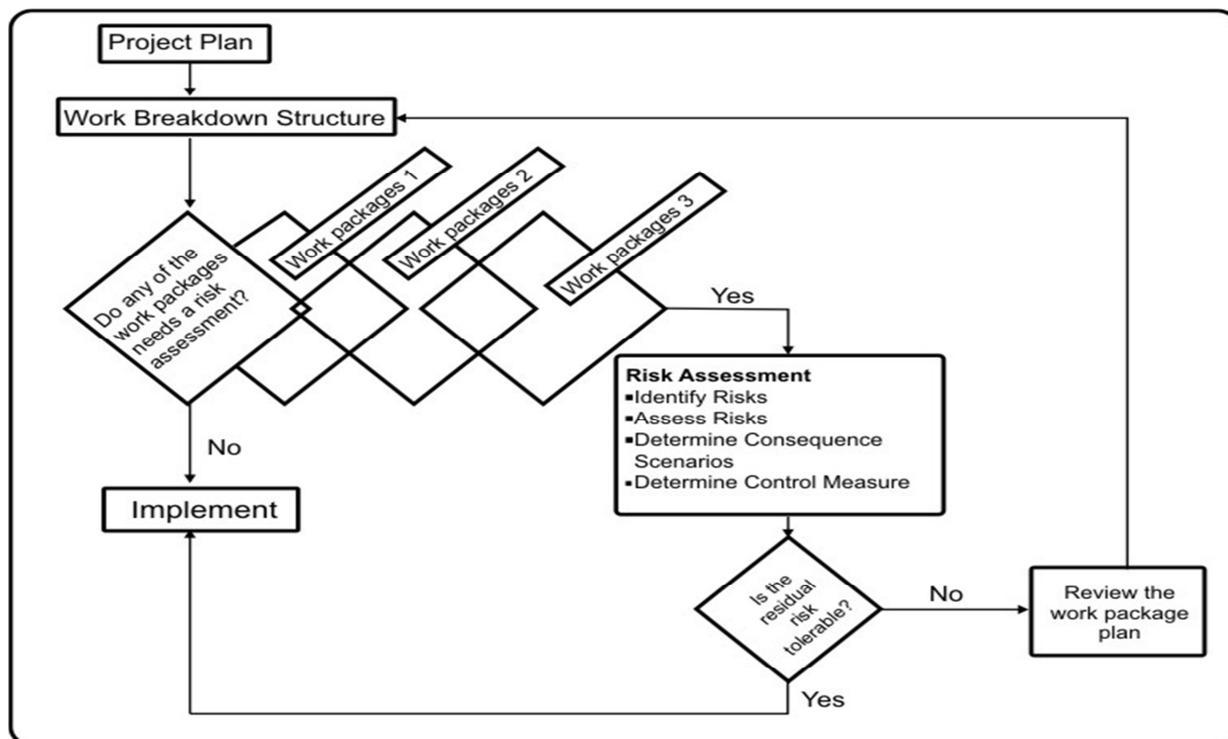


Figure 2: Risk Management Flow Chart, (Dey, 2002)

4. The Cost of Capital

Capital like any other factor of production has a cost. In financial engineering, cost of capital commands primary consideration because of its impact on the success or failure of projects and ultimate wealth of a firm.

A company's cost of capital is the weighted average cost of the various sources of finance used by it, viz, equity, preference, long term debt, and short term debt.

The cashflows of a capital investment may be viewed from various points of view: the equity point of view, the long-term credit funds point of view, the explicit cost funds point of view, and the total funds point of view. The discount rate applicable to the different types (or sources) of funds must be consistent with the firm's/project's approved objective(s). The standard practice in capital budgeting is to look at the cashflows from the point of view of explicit cost funds (referred to also as investor claims) and apply the weighted average cost of capital of the firm as the discount rate. (See table 1 below)

Table 1: Calculation of the WACC for Orient Oil/Gas Co. Ltd.

Source of capital	Proportion (1)	Cost (2)	Weighted cost (3) = (1) x (2)
Debt	0.60	16.0%	9.60%
Preference	0.05	14.0%	0.70%
Equity	0.35	8.0%	2.94%
Weighted Average Cost of Capital WACC =			13.24%

The cost of capital is a central concept in financial engineering and management of projects (Chandra, 2002). It is used for evaluating investment projects, for determining the ideal capital structure, for assessing leasing proposals, for setting appropriate borrowing and lending rates at which an investment can be feasible, breakeven or viable or fit rate set by regulated organization.

Thus if a firm's rate of return on its investment exceeds its cost of capital, the wealth of equity stockholders is enhanced.

A firm's cost of capital is the weighted average costs of various sources of finance used by it (e.g. equity, preference, long-term debt and short-term debt). Omitting cost of any of this type of funds in calculating WACC will misstate the rate of return required on capital investments. Hence WACC for 'N' different sources of finance for a project is $\sum_i^n P_i r_i$ (where P_i is the proportion of the i th source of finance, r_i is the cost of the i th source of finance. Strictly speaking WACC is the right discount rate for a project that is a carbon copy of the firm's existing business and will not require change in firm's capital structure as its risk is same with the average

risk of existing investment. Thus, WACC is used as benchmark/hurdle rate which is adjusted for variations in risk and financing patterns.

The components of capital structure include: equity, debt and preference stock. Cost of debt (i.e. debenture, bank loans, and commercial papers) and preference stock are relatively easier to estimate than equity cost.

Cost of debt is the average rate of different kinds of debt employed by the firm.

Preference capital carries a fixed rate of dividend paid to preference shareholders and is redeemable in nature even though obligation to redeem is not as firm as that towards debenture holders. It is more like a bond with fixed commitment. But preference dividend unlike debt interest is not a tax-deductible expense and hence does not produce any tax saving. The cost of preference stock is simply equal to its yield.

5. Costs of Equity

Equity finance may be obtained through (1) use of retained earnings (2) issue of additional equity. The cost of equity (i.e. return required by equity holders) is the same in both cases. The difference is that there is no floatation costs for retained earnings. While new additional, equity has a 2-10% floatation cost.

Generally, cost of equity refers to the cost of retained earnings and external equity. But because there is no definite commitment on the part of the firm to pay dividends on equity the cost of equity is more difficult to estimate than that of debt and preference stock. The methods of estimating costs of equity include use of: Security market line (SML), Bond yield plus Risk Premium approach; Dividend growth model Approach, Earnings – price ratio approach – etc. these are treated elsewhere in detail. Cost of equity is equal to the dividend rate of return on equity.

6. Weighted Marginal Cost of Capital

WACC does not remain the same as fund suppliers provide more funds to increase the magnitude of financing. Thus WACC tends to rise as the firm seeks more and more capital, i.e. rate of return required by fund suppliers tend to increase. The schedule or graph showing the relationship between additional financing and the WACC is called weighted marginal cost of capital schedule (see table 2 below).

Table 2: Weighted Marginal Cost of Capital WMCC Schedule for Orient Oil/Gas Co. Ltd.

Source Of Capital	Target Proportion	Range of new financing N-million	Cost
Equity	45%	0 – 10	15%
		10 – 30	16.5%
		30 and above	18.0%
Reference	5%	0 – 1	14.5%
		1 and above	15.0%
Debt	50%	0 – 15	7.5%
		15 – 40	8.0%
		40 and above	8.4%

7. Marginal Cost of Capital and Capital Budgeting

A project is worthwhile if its NPV, discounted at the marginal cost of capital is positive.

Financial Institutions calculate cost of capital as post-tax weighted average cost of the mix of funds employed for the project.

The cost for different sources are taken as follows (Chandra, 2002)

- Equity share capital – 15%
- Cash accruals/Retained earnings – 15%
- Preference share capital – preference dividend rate
- Subsidy/incentive loans – zero cost
- Debt (long term loans, non convertible debentures, deferred credits, bank borrowings for working capital, unsecured loans from public) – post tax rate of interest
- Convertible debenture – 15%
- Non convertible portion - post-tax interest rate.

When a firm raises finance by issuing equity and debt, it almost invariably incurs floatation or issue costs, comprising items like underwriting costs, brokerage expenses, fees of merchant bankers, under-pricing

costs etc. WACC can be adjusted to reflect floatation cost. Depreciation – generated funds as a source of firm’s fund, has its cost as the average cost of capital to the firm. Because, depreciation funds if returned to the firm’s shareholders and lenders (which provided the finance for the asset acquisition) can be invested by them to yield income which is the opportunity cost of the internal use of depreciation funds and this approximates the firm’s average cost of capital.

9. Risk identification

9.1 Why identify risk?

Every business decision involves costs and benefits and hence risk. And the risk increases as this investment extends over a long time during which many things can change in unanticipated ways. As earlier highlighted in capital budgeting, the use of WACC of firm assumes that risk of proposed investments is same as that of existing investment. But risks of proposed investments often differ from risk of existing investment and as such this variation in risk need to be identified and explicitly planned, evaluated and systematically managed in capital investment projects.

The important sources of risk in projects include:

- Project specific risk
- Competition risk
- Industry specific risk
- Market risk and
- International risk

Project Specific Risk – The earnings and cash flows of the project may be lower than expected because of estimation error or other factors specific to the project like quality of management.

Competition Risk – Project earnings/cash flows are affected by unanticipated actions of competitors.

Industry Specific Risk – New technological developments and regulatory changes that are specific to the project industry, thus impacting project earnings and cash flows.

Market Risk – Unanticipated changes in macro-economic factors like the GDP growth rate, interest rate, and inflation rate impacting on all projects in varying degrees.

International Risk – Hightech projects having high import factors with vacillating exchange rate, imported inflation and political risks impacting earnings and cash flows.

9.2 Other perspective on risk includes:

- Stand-alone project risk-which is risk of a project viewed in isolation.
- Firm risk – which considers the contribution of a project to the risk of the firm and
- Systematic risk – which views integratively the risk of diversified investments often called market risk.

In most firms the capital budgeting committee considers investment proposals one at a time and may not have time or information or expertise to fully consider the interactions of the investments with other investments of the firm and its shareholders.

9.3 Measuring Risk

Measures of risk:

Risk of variability of return from the appraised NPV or IRR is first considered using:

- (1) Range – the difference between pessimistic cost and optimistic cost or optimistic NPV minus pessimistic NPV.
- (2) Standard Deviation (SD) is the most commonly used measure of risk in finance but has the problem of not considering scale of return.
- (3) Co-efficient of variation (CV) is applied to adjust standard deviation for scale.

$$\text{Hence C.V} = \frac{\text{Standard deviation}}{\text{Expected value}}$$

- (4) Semi-variance: is used to address the second problem of standard deviation (SD) of considering all deviations from expected value, positive (+ve) as well as negative (-ve), in the same way. But investors worry only about negative deviations. Semi-variance is computed in the same way as variance but considers only outcomes below the expected value i.e., -ve deviations. The following example illustrate these measures:

Consider a capital investment with the following distribution of Net present values (NPVs)

NPV 200 600 900
 Probability 0.3 0.5 0.2
 The expected NPV $E(NPV) = \sum P_i NPV_i$
 $0.3 \times 200 + 0.5 \times 600 + 0.2 \times 900 = 540$
 Range = $900 - 200 = 700$

Standard Deviation, $\sigma = \left[\sum p_i (X_i - X)^2 \right]^{1/2}$

NPV (X _i)	Probability (P)	Exp. NPV (X̄)	Deviation (D)	D ²	P(D ²)	Variance
			$X_i - \bar{X}$	$(X_i - \bar{X})^2$	$P (X_i - \bar{X})^2$	$\sum P_i (X_i - \bar{X})^2$
200	0.3	60	200 - 540	(-340) ²	0.3(-340) ²	34,680
600	0.5	300	600 - 540	(60) ²	0.5(60) ²	1,800
900	0.2	180	900 - 540	(360) ²	0.2 (360) ²	25,930
		540	80	6400		62,400

Variance (D)² = 62,400
 Standard Deviation, $\sigma = \sqrt{62400} = 249.79 \approx 250$

Based on standard deviation selection criteria, project with NPV N10m and σ , N100,000, may be rejected while that with NPV 1m and σ , N80,000 may be accepted.

Coefficient of variation (CV) corrects this anomaly by adjusting standard deviation to the size of expected NPV value.

$$CV = \frac{\text{Standard deviation}}{\text{Expected value}} = \frac{250}{540} = 0.46.$$

Semi-Variance = S.V. = $\sum P_i D_n^2$

Where D_n = -ve deviations.

Semi-variance for our case illustration $SV = 0.3 (200 - 540)^2$
 $= 0.3 (-340)^2 = 34680$

Semi - Standard deviation = $\sqrt{34680} = 186.2$

10. Sensitivity Analysis (What – if – Analysis)

Given the uncertainty of future and business climate one would like to know whether forecasted viability (NPV or IRR) of a project still stands when variables like forecasted sales or investment or macroeconomic factor deviates from its expected value.

These underlying variables can vary widely and hence you should seek to explore the effect of such variations on the project NPV. Hence sensitivity analysis indicates the sensitivity of the NPV or IRR which is the criterion of merit. Evaluation of sensitivity analysis enables us appreciate how robust or vulnerable a project is to changes in values of the underlying variables. Thus highlighting area where further work needs to be done. If project NPV is highly sensitive to changes in some factor, it points out the need to explore how the variability of that critical factor may be contained/controlled.

The obvious weak point of sensitivity analyses is that it merely shows impact on NPV of change in any of the underlying variables taken one at a time without showing likelihood of having such a change.

In the real world, changes in underlying variables often occur simultaneously (concurrently) and the impact may lead one decision maker to accept and another to reject the project.

10.1 Scenario Analysis

Seek to address the weak point of sensitivity analysis of considering the changing variables one at a time. Scenario analysis consider inter-relationship of variables/variations in variables together. It looks at some plausible scenarios with each scenario representing a combination of variables.

Scenario analysis selects largest factor or source of uncertainty that impacts the success of a project and estimate values of each of the investment variables (outlay, revenues, costs, lifespan under such scenario and calculate the NPV/IRR under each scenario. It deduces the best and worst case scenarios, get a feel of what happens in each and make decision/advise accordingly.

10.1.1 Limitations of Scenario Analysis:

- It is based on the assumption that there are few well-delineated scenarios. This may not be true in many cases. For instance, the economy does not necessarily lie in three discrete states, viz recession, stability and boom. It can, in fact, be anywhere on the continuum between the extremes. When a continuum is converted into three discrete states some information is lost.
- Scenario analysis expands the concept of estimating the expected values or project cash flow or profiles. Thus estimating project profiles for all identified scenarios is tasking.

10.2 Break even analysis

As financial engineers and cost managers of both process plant/construction projects you should be able to tell at what level or volume of production and sales the project will breakeven or not lose money i.e. breakeven analysis. Just like in sensitivity analysis you try to ascertain what will happen to the project if sales decline or costs increase or any macro factor changes. In breakeven analysis the minimum quantity at which loss is avoided is called the breakeven point quantity while the sales is breakeven value BEV and the price is the breakeven price below which the product should not be sold or the project will incur a loss, and Contribution margin toward recovery of fix cost is 1 -

Where VC = variable cost and S = sa

Pricing project at breakeven rate merely enables the business/ contractor to pay his overhead and stay in business without profit or compensation for opportunity cost of his capital foregone or his entrepreneurial risks. Such a project will have zero NPV.

This is why it is not proper to adopt bill rate of completed projects without full information and expert factoring.

10.3 Simulation Analysis

Sensitivity analysis indicates the sensitivity of the criterion of merit (NPV, IRR etc) to variations in basic factors and provides such information as; if the quantity produced and sold decreases by 1%, other things being equal, the NPV falls by 6%. Such information, though useful, may not be adequate to decision maker, who would also like to know the likelihood of such occurrences. This information is generated by simulation analysis which may be used for developing the probability profile of a criterion of merit (e.g. NPV) by randomly combining values of variables which have a bearing on the chosen criterion. Thus simulation provide answer to questions such as what is the probability that NPV will be less than zero, equal to zero or any value etc or IRR less than x%. This is equally obtained through PERT analysis. (See. Ajator, 2012, Project Cost Control Fundamentals).

10.3.1 Procedure:

- (1) Model the project. The model of the project shows how the net present value is related to the parameters and the exogenous variables. (Parameters are input variables specified by decision maker and held constant over all simulation runs. Exogenous variables are input variable which are stochastic/non deterministic in nature and outside the control of the decision maker).
- (2) Specify the values of the parameters and the probability distributions of the exogenous variables.
- (3) Select a value, at random, from the probability distributions of each exogenous variable.
- (4) Determine the NPV corresponding to the randomly generated values of the exogenous variables and the pre-specified parameter values.
- (5) Repeat steps (3) and (4) a number of time to get a large number of simulated NPVs.
- (6) Plot the frequency distribution of the NPV (and finally fit the standard frequency distribution of the NPVs). Monte Carlo simulation is popular in this process. Because of computational tedium, simulation is best done only on the computer.

10.4 Decision Tree Analysis

Decision tree is a useful tool for analyzing sequential decisions in the face of risk. Decision tree reflects in a diagrammatic form the nature of the decision situation in terms of alternative courses of action and chance outcomes which have been identified in the first step of the analysis.

The key steps in decision tree analysis are:

1. Identify the problem and alternatives
2. Delineate the decision tree
3. Specify probabilities and monetary outcomes
4. Evaluate various decision alternatives

To identify the problem and alternatives, you have to understand the problem and develop alternatives; obtain information from different sources – marketing research, engineering/technology studies, economic forecasting, financial analysis etc. And use imaginative efforts to identify the nature of alternatives that may arise as the decision situation unfolds itself and assess the kinds of uncertainties that lie ahead with respect to availability of raw material and power, technological changes, competition action and government regulation. Recognizing risk and uncertainties inherent in these investment variables for each alternative solution is imperative. You must feel confident to express your doubts uncertainties and reservations and suggest contingency plans/emergent promising opportunities, in the form of decision tree. Next to development of decision tree follows assessment of:

- Probabilities associated with each of the possible outcomes (using experience, judgment and intuition, understanding/ expert knowledge of executives) and
- Monetary value of each combination of decision alternative and chance outcome (assessing cash flows for

monetary value requires expert judgment).

10.4.1 Evaluating the Alternatives

From the delineated decision tree and probabilities and monetary values data gained, decision alternatives maybe evaluated thus:

- (1) Start at the right hand end of the tree and calculate the expected monetary value at various chance points that come first as we proceed leftwards.
- (2) Given the expected monetary values of chance points in step 1, evaluate the alternatives at the final stage decision points in terms of their expected monetary values.
- (3) At each of the final stage decision points, select the alternative which has the highest expected monetary value, and truncate the other alternatives. Each decision point is assigned a value equal to the expected monetary value of the alternative selected at that decision point.
- (4) Proceed backward (leftward) in the same manner, calculating the expected monetary value at chance points, selecting the decision alternative which has the highest expected monetary value at various decision points, truncating inferior decision alternatives, and assigning values to decision points, till the first decision point is reached.

Financial Institutions Analyze Project Risk Using: Breakeven point, debt service coverage ratio and sensitivity analysis.

11. Project Selection Under Risk

A project corporate risk is its contribution to the overall risk of the firm. A project with high NPV may not be selected (as earlier demonstrated) if its assessed risk is very high. If standard deviation or co-efficient of variation associated with achieving that NPV or expected return is very high (risk/return trade off).

There are several ways of incorporating risk in project selection decision process, viz: judgmental evaluation, payback period requirement, risk profile method, certainty equivalent method and risk adjusted discount rate method (which adjust discount rate to fit project risk). Note that if risk of project is the same with risk of existing investments of firm, the firms cost of capital is not adjusted. But higher or lower discount rate is used if project risk is higher (e.g. new investments) or lower than firms existing investment risk.

The risk adjusted discount rate is $r_k = i + n + d_k$

Where: r_k = risk adjusted discount rate for project k

i = risk free rate of interest

n = adjustment for the firm's normal risk

d_k = adjustment for the differential risk of project k.

once the project's risk adjusted discount rate r_k is specified the project is accepted if its NPV, calculated by substituting r_k in the model $NPV =$

$$\sum_{t=i}^n \frac{\overline{At}}{[1 + r_k]^t} - \text{Outlay is positive.}$$

Where \overline{At} = expected cash flow for year t

r_k = risk adjusted discount rate for project k.

Hence for a project having risk adjusted discount rate of 18%, outlay N1,000,000 and expected cash flows N200,000; N300,000; N400,000; N300,000; and N200,000 for years 1 to 5 respectively, the NPV =

$$NPV = \frac{200,000}{(1.18)^1} + \frac{300,000}{(1.18)^2} + \frac{400,000}{(1.18)^3} + \frac{300,000}{(1.18)^4} + \frac{200,000}{(1.18)^5}$$

= -N124,440 is not viable

Certainty Equivalent Method:- applies certainty equivalent co-efficient on expected uncertain stream of cash flows to transform them into their certainty equivalents, before discounting to get the NPV.

11.1 Managing Risk Systematically

As project cost managers you should not merely be content with measuring risk. You should also explore ways of mitigating and managing risk of projects systematically, viz:

- Identify risk
- Assess/measure impact magnitude
- Plan response strategy(ies)
- Implement strategy
- Measure actual/compare with plan strategies
- Identify deviation
- Plan, implement and document corrective measures for managing risk of future projects (see figure 1:

Integrated framework for financial engineering and project risk management).

11.2 Risk Mitigating and Response Strategies

These include but not limited to application of:

- Fixed and variable cost modification to reduce breakeven level.
- Pricing strategy: high price reduce breakeven point
- Appropriate sizing/low to high capacity utilization in business – use decision tree analysis to judge the better sequence; high initial capacity or low to high capacity utilization.
- Perfect information: reduce risk but create study cost/delay which is expensive in business.
- Pay back method: to be used to fine-tune selection of projects with equal NPVs. Insist on shorter payback period.
- Financial leverage: reduce gearing; use more equity than debt financing.
- Insurance: pay premium and get insurance cover against variety of risk.
- Proper estimating: estimate project revenues conservatively and check optimism common among project sponsors.
- Avail benefit of learning curve: serial contracting, business partnering, strategic alliancing and total quality management (TQM) – enter into indexed/unindexed long-term arrangements with suppliers, employees, lenders and customers. Long term debt reduce risk of interest rate, while long term sales' contract with customers eliminates revenue risk. Price indexing protects both the buyer/seller against inflation risk.
- Strategic alliancing/joint venture and financial syndication: - could be used for financing major capital projects etc.
- Total quality management – insists on getting things done right first time to eliminate error risks and wastes at lowest overall lifecycle cost.
- The massive resource requirements and huge risks in modern enterprises have compelled many traditional rivals (competitors) to work together and be less insular, leading to a new phenomenon called 'cooption' instead of competition.
- As financial and cost engineers in volatile investment market, you should be able to advise project sponsor(s) on when to issue front-end debt instrument, with redeemable option or syndicated loan to gain immediate project commencement fund and the right to prematurely redeem (buy back) the debt instrument when firm secures long term debenture with moratorium and liberal interest terms ideal for financing mega industrial plant project.
- Futures contract: you should also advise on “futures contract” arrangement for acquiring critical main plant items (assets) at a predetermined future date at a price that is fixed or specified today to eliminate price risk.
- Margin of safety – Try to include appropriate margin of safety in estimating cost figures (say 10%-30%) depending on management perception of likely variation in cost of equipment, materials and labour.
- Certainty index/three point estimate of returns/conditional success probability: apply acceptable overall certainty index or better still, base judgment of projects on three point estimate of returns on the project – most pessimistic, most likely and most optimistic, using conditional success probability of the 3 point estimate A, B, and C e.g. $P(A) \times P(B/A) \times P(C/A\&B)$ and not $[P(A) + P(B) + P(C)]$ as defined by overall certainty index method.

11.3 Systematic Management of Risk

Risk management has to be systematic and applied in a disciplined manner to minimize losses and enhance profitability, especially where project risk is high with significant impact on the project goal.

Kim and Bajai (2000) structured a systematic risk management practice methodology (SRMPM) for use by South Korean contractors in handling construction risk. It encompasses seven step actions; which define objective, identify risk, quantify risk, develop a risk response, document the risk management plan, manage risk and assess outcomes.

In systematic risk management each action step should logically, sequentially and progressively inter-connect. Risk management goals like financial engineering, are best derived from overall corporate business objectives, policies and project objectives, with carefully defined scope. It should pose action-oriented questions:

- Who is doing the analysis and what benefits could be achieved?
- What are the resource requirements cost, compared to benefits?

Identifying risk—involves classifying them according to their type, frequency and consequences. The possible steps include:

- Check the existence of uncertainty by reviewing the project model
- Prepare tools and techniques for all sources of risk
- Identify/categorize every potential risk and their consequences

- Develop formal risk handling plan
- Prepare a summation for every risk category and
- Identify the need for further action
- Use simple project risk checklist in doing these.

11.4 Quantifying Risk

- Apply quantitative techniques earlier exposed in quantifying and ranking risks.
- Refine initial scope estimates of identified risks.

Quantifying risk generally provides an in-depth understanding of the sources of and degree of risk, thus enabling clear communication of the project's scope / status to decision makers.

Developing a risk response, centre's on evolving effective actions to be taken to address the risks as earlier exposed. The manner of risk, its probability and severity guide decision on appropriate response strategies of risk; avoidance, risk control and risk retention. Finally develop a corrective action summary comprising list of risk issues, their consequences and mitigating measures.

Document Risk Management Plan by developing a list showing risk issues, consequences and cost of mitigation strategies. Manage risk by putting the risk management plans into action.

Finally assess risk management outcome of implementing risk management plan. Carryout constant review/update of risk management plan as may become necessary and consider retraining of staff to fit the challenge of systematic management of project risks.

12. Conclusion and Recommendation

The foregoing treatise has taken a panoramic view of the concept of financial engineering and project risk management. It crafted a functional integrated framework of financial engineering and risk management. The intent is to break the inertia which had prevented professional Quantity Surveyors from carrying out their traditional cost management practices in the process industries. Familiarity with the exposed tools, techniques and skills are imperative for practicing quantity surveyors because they are the cutting edge for success in project control and management of operational plants.

Application of the framework and the implicated tools will imbue the Quantity Surveyors with knowledge, skill and confidence to become major players in the development and management of the nation's infrastructures to reduce risk, reduce cost, enhance economic development and add-value to the national economy.

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