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Project Economics as a Tool for Evaluation of Viability of Projects: A Case of Palm Oil Milling Plant *(pp. 307-318)*

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Abstract: In this research work, a case study of a proposed palm oil milling plant by an entrepreneur is looked into. This is with a view to ensuring its Viability, and also delving into the Risk, Uncertainty and Sensitivity Analysis of vital parameters. At the end of all analyses, the entrepreneur is well guided to take a decision on whether or not to commit his or her scarce resources. Basic engineering economy methods for project evaluation are highlighted. With the added information from the sensitivity analysis the investor would be better informed about critical factor and therefore could take appropriate actions.

Keywords: engineering project, Economy, sensitivity analysis, cost benefit.

1. INTRODUCTION

As Engineers, we are likely to spent part or greater part of our professional carrier in management positions. As such, in one way or the other, we are going to be faced with the task of making decision that tends to have long term effect on the performance of business particularly with regards to remaining competitive; as well as gaining competitive advantage within an industry.

The task of making investment decisions that would enhance profitability might be difficult in the absence of sufficient and reliable information, on which one judgment would be based. The task becomes even more difficult when it involves economic evaluation of engineering project involving risk uncertainty and sensitivity analysis. The research work is looking into the evaluation of the viability of a proposed business (Palm Oil Milling Plant); and carry out sensitivity analysis on capacity utilization, selling price of the product, useful life of plant and raw materials cost. At the end of evaluation and analysis, the entrepreneur would be well positioned to take decision whether to finance the business.

The purpose of engineering economic analysis is to establish that a technically feasible project is also economically viable. The result of the analysis plus other consideration such as legal frame work, risk, uncertainty and sensitivity analysis, e.t.c would assist interested entrepreneur in making a decision whether or not to commit his scarce resources to the project. Because patterns of capital investment, revenue (or savings) cash flows and cost cash flows can be quite different in various projects, there is no single method for performing engineering economic analysis that is ideal for all cases. Consequently, several methods are commonly used in practice. All the methods produce equally satisfactory results and lead to the decision in cases where the inherent assumptions of each method are applicable. Inherently, the purpose of embarking on any project is the envisaged profit. To ensure profit, a high level of cost management must be employed.

2. BASIC ENGINEERING ECONOMY METHODS FOR PROJECTS EVALUATION

The following methods are commonly used:

Net Present Value (NPV) or Present Worth (PW) Method

The Net present value of a series of cash flows refers to the equivalence of a single sum of money to be received or disbursed at time (t = 0) if all future receipts and disbursements over the time are properly discounted to the present time and then summed algebraically. This model is specified (Au and Au, 1983) as

$$NPV = \sum_{t=0}^{n} A_{t-X}(1+i)^n = \sum_{t=0}^{n} A_{t-X}\left(\frac{P}{F}\right), i\%, n$$

Where;

A_t-x	=	the net cash flow for project "X" at year t(t=0, 1,..n).
n	=	Project life cycle
i	=	The Minimum Attractive Rate of Return (MARR)

(P/F, i%, n) can be obtained from the universal interest table (see appendix. A). and the interest rate factor ranges from 0.25% to 50%. The NPV as expressed above is based on the concept of equivalent worth of all the cash flows, relative to some base, a beginning point in time, called the present. That is all cash inflows and outflows are discounted to the base point at an interest rate (i%), which is the MARR (DeGarmo et al, 1979). NPV = PW is widely used by investors because of its easy computation.

The MARR is usually choosen to maximize economic well being of an organization (DeGarmo et al., 1979).

(a) The amount of money available for investment, and the source and cost of these funds.

(b) The number of good projects available for investment and their purposes.

(c) The amount of perceived risk that is associated with investment opportunities available to firm and the project cost of administrating, the project over a short planning horizon versus a long planning horizon.

(d) The type of organization involved (public or competitive industry), private competitive industries, frequently employ the opportunity cost view point towards choosing MARR.

Net Future Value (NFV) or Future Worth (FW) Method

The NFV of a time series of cash flows refers to the equivalence of a single sum of money to be received as disbursed at some future time (t = n) if all receipts and disbursement over time are properly compounded to that future point in time and summed algebraically.

For a given series of net cash flows A_t-x for a project "X" over a planning horizon of "n" years, and a given value of MARR as previously defined, the net future worth model of the series is given by (Au and Au 1983).

$$NPV = \sum_{t=0}^{n} A_{t-X}(1+i)^{-n} = \sum_{t=0}^{n} A_{t-X}(P/F), i\%, n$$

The NFV is exactly comparable to NPV except that cash inflow and out flows are compounded forward to a reference point in time called future (DeGarmoetal, 1979). The project is worthwhile economically, if NFV$\geq$ 0

Annual Worth (AW) Method

The normal of a project is its annual equivalent receipts, minus annual equivalent expenses, less its annual equivalent capital recovery. The capital recovery cost for a project is the equivalent uniform costs of the capital invested, which include depreciation and "interest on the invested capital (DeGarmo et al, 1979). The project is economically attractive if AW $\geq$ 0

Internal Rate of Return (IRR) Method

The IRR method solves for the interest rate that equates the equivalence of cash inflows to the equivalent worth cash outflows. The equivalent worth may be computed by using any of the present worth formulation, the IRR is i% at which;

$$NPV = \sum_{k=0}^{n} R_{k\ (P/F),\ i^1\%,K)} \sum_{k=0}^{n} E_{k\ (P/F),\ i^1\%,\ K)}$$

where;

R_K = net receipt or savings for the K^{th} year

E_K = net expenditure, including investments, for the K^{th} year
n = as previously defined

The project in question is acceptable as long as i ≥ MARR, otherwise it is not (DeGarrno et al., 1979). This method is the most widely used rate of return method for performing engineering economic analysis. It is called several other names such as;

- investors method
- Discounted cash flow method
- Profitability index

However, the rigour of the computation and the possibility of multiple rates of return are the major pitfalls of the method.

External Rate of Return (ERR) Method

The ERR method takes into account the external interest rate (e %) at which the net flows generated by a project over its life can be reinvested outside the firm. In general, all cash flows are discounted to the present at e% per compounded to a period "n" at e%. The ERR is then the interest rate that establishes equivalence between the two quantities. Mathematically, ERR is the interest rate (i%) at which;

$$\sum_{k=0}^{n} E_{k\,(P/F,\ e\%,K)(F/P,i\%,n)} \sum_{k=0}^{n} R_{k\,(F/P,\ e\%,\ n-K)}$$

where;

R_K = excess of receipt over expenditure in period k
EK = excess of expenditure over receipt in period k.
n = project life
e = external reinvestment rate per period.

The project is acceptable if i% ≥ MARR.The method unlike, IRR, is easier to solve and is not subject to multiple rate of return (DeGarmo et al., 1979; De la Mare, 1990).

Benefit Cost Ratio (BCR) Method

The BCR is the ratio of discounted benefits to the discounted cost with reference to the same point in time. Mathematically,

$$\frac{\text{NPV(income)}}{\text{NPV(expenditure)}} = \frac{\text{PWcash inflow}}{\text{PWcash outflow}}$$

If BCR ≥ 1, then the project is attractive

Pay Back Period (PBP) Method

Present Worth (PW), Annual Worth (AW), Future Worth (FW); Internal Rate of Return (IRR); External Rate of Return (ERR) and Benefit Cost Ratio (BCR) reflect the profitability of alternative for a study period of "N". The payback method mainly indicates;

- A project liquidity rather than its profitability.
- The recovery rate of a project (how fast a project can be recovered).

Simply, the payback method calculates the number of years required for positive cash flows to equate to the total investment "I".

Hence, the simple payback period is the smallest

θ (θ = N) for which

$$\sum_{k=1}^{\theta}(R_{k-} E_k) - 1 \geq 0$$

θ - ignore the time value of money and all cash flews after θ.

It however takes into consideration the salvage value when Θ = N

However, when value of money is considered, then the discounted payback period θ^1 (θ^1 < N) is calculated as follow:

$$\sum_{k=1}^{\theta^1}(R_{k-}E_{k-})(P/F, i\%, K) - 1 \geq 0$$

Where;

i% = MARR

I = investment made at present time K = 0

θ^1 = the smallest value N that satisfies the equation above

The use of the payback period should be avoided for making economic decision except when used as quick measure of how capital can be recovered.

3. RISKS, UNCERTAINTY AND SENSITIVITY ANALYSIS

In engineering economic analysis, it is assumed that a high degree of confidence could be placed in all estimated values. This degree of confidence is sometimes called "assumed certainty". Decisions made solely on this kind of analysis are sometimes called decision under certainty.

However, in real terms, there is rarely a case in which estimated quantities can be assumed as certain. A degree of doubt is usually associated with the results that will be eventually obtained from an investment. The need to establish the limits of error in our estimates in order to make our choice better than one based on assumed certainty makes risk, uncertainty and sensitivity analysis desirable.

Risk
Decisions under risk are those in which the analyst models the decision problems in terms of assumed possible future outcomes whose probabilities of occurrence can be estimated.

Uncertainty
Decision under uncertainty is a decision problem characterized, by several unknown futures for which probabilities of uncertainty cannot be estimated. In reality the difference between risk and uncertainty is arbitrary as both can cause study results to vary from predictions. There are four main sources of uncertainties when making economic studies:

(a) Possible inaccuracy of income and expense estimates used in the study.
(b) Type of business involved in relation to the future health of the economy.
(c) Type of physical plant and equipment involved.
(d) Length of the assumed study period.

Sensitivity
The determination of the extent to which changes in an estimate would alter an investment decision depicts the sensitivity of the investment to changes in that

particular factor that is not known with certainty. For instance, if a factor such as project life could be varied over a wide range without causing much effect on the investment decision, that decision is said not to be sensitive to that particular factor. On the other hand, if a small change in the relative magnitude of a factor will significantly affect an investment decision, the decision is very sensitive to that factor. Sensitivity analysis is one of the numerous methods of dealing with uncertainty. The basic objectives of sensitivity analysis are:

- ✓ To determine the behaviour of the measure of merit to changes in each individual factor.
- ✓ To determine the amount of change in a particular factor that will reverse the preference for an alternative.

Case Study

An entrepreneur is considering an investment on a palm oil milling plant in a developing suburban area (Ogharefe town to be precise) in Delta state. From a preliminary study, the following estimates are made.

Estimated duration of market opportunities	= 10 years
Estimated capacity utilization of plant	= 75%
Working days/year	= 250 days
Initial cost of plant	= $100.000
Capacity of plant (volume of milled oil/day)	= $72m^3$
Salvage value at the end of 10 years (plant)	= $20.000
04 delivery trucks at $8,000 each	= $32.000
Useful life of delivery trucks	= 5 years
Trade- in values of trucks after 5 years	= $500 each
04 truck drivers at $ 50.00 each/day	= $200/day
04 Operators	= $175/day
Annual Operating and Maintenance cost (O&M)(plant)	= $7,000
Annual operating and maintenance cost (4 Trucks)	= $9,000
Raw materials cost	= $27.0/m^3
Payroll taxes, vacations benefits etc.	= 25% of annual pay
Annual taxes and insurance (4 Trucks)	= $2,000
Annual taxes and insurance (Plant)	= $1.000
Annual salary of manager	= 20,000
Selling price per m^3	= 45
Plant useful life	= 10 years
Interest rate	= 15%

TASK: Evaluate the viability of the venture and carry out a sensitivity analysis of the most important parameters.

Viability solution applying AW method

Annual revenue		$	$
72× 250 ×$45 × 0.75 =		607.500	
Annual costs:			
1. capital recovery plant $ 100,000 (A/P, 15%, 10)			
-20,000 (A/F, 15%,!0)	=	18.940	
Trucks: 4[$800(A/F, 15%, 5)			
- $500(A/F, 15%,5)]	=	9.250	28.190
2. Labour			
Operator: $ 175×250	=	43.750	
Truck drivers: 4×$50×250	=	50.000	
Manager	=	20,000	113,750
3. Payroll taxes, benefit etc $ 113,750 × 0.25	=		28.438
4. Taxes and Insurance of Pant	=	1.000	
Trucks	=	2.000	3.000
5. Operations and Maintenance at 75% capacity			
Plant	=	7.000	
Trucks	=	9.000	16.000
6. Materials			

72 × 0.75 ×250 × $27	=		364,500
		Total	**535,878**

AW = AR – AC = 607,500 – 553,878 = $ 53.622

- **The project is an attractive investment opportunity**

Sensitivity Analysis

The most important parameters that must be analyzed are: (i) capacity utilization (ii) Selling price of product. (iii) Useful life of plant and (iv) raw materials cost. The raw materials cost would be equally beneficial to competitors and probably would rolled in a corresponding change in selling price. Therefore, we would like to investigate the first three factors.

Sensitivity of Capacity Utilization

The first step is to determine how cost factors would vary with wide variation in capacity utilization. In the example cost items in group 1, 2, 3 and 4 would be virtually unaffected. The group 5 costs for operation and maintenance would be affected somehow.

- Secondly, we must either determine what the variation would be or make a reasonable assumption.
- Assumption: Half of the cost in group 5 will be fixed while the other half will vary with capacity utilization by a straight-line relationship.

i.e. if X = annual operating and maintenance cost at 100% capacity utilization. Using **75%** capacity utilization data, solve for X.

X/2 + (X/2)(0.75)	=	$ 16.000
X+0.75X	=	16.000
2I.75X	=	32000
X	=	18.286

Annual operating and maintenance cost at 100% capacity utilization is $18.286

At 50%

O & M cost = $\frac{18286}{2} + \frac{(18286)(0.5)}{2}$ = $I3.7I5

At 65%

O& M cost = $\frac{18286}{2} + \frac{(18286)(0.65)}{2}$ = $ 15. 086

At 90%

O & M cost = $\frac{18286}{2} + \frac{(18286)(0.9)}{2}$ = $17.372

Revenue and cost of materials: will vary in direct proportion to capacity utilization.

If y = % capacity utilization

Annual revenue =607500/75 x y

Cost of materials 364.500/75 x y

Table 1: Annual worth for the plant

	50% capacity	**65% capacity**	**90% capacity**
Annual revenue	405.000	526.500	729.000
Annual costs:			
Capital recovery	28.190	28.190	28.190
Labour	113.750	113.750	113.750
Payroll taxes e.t.c	28.438	28.438	28.438
Taxes and insurance	3,000	3,000	3,000
Operation and Maintenance	13,715	15.086	17.372
Materials	243.000	315.900	437400
Total costs:	430.000	504.364	628.150
A W	-25.093	+ 22.136	+ 110.850

Deductions

- Annual worth moderately sensitive to capacity utilization
- The plant could still be operated profitably at a little less than 65% capacity instead of the assumed 75%

- The annual worth would be very good if operated above assumed 75% capacity.

Sensitivity to Selling Price

Assumption:

- plant would operate at 75% capacity
- cost would remain constant
- selling price would vary

Annual revenue =72×250 ×0.75×SP

SP = Selling Price

Table 2: Effect of selling on the Annual worth for the plant at 75% capacity

	SP = $45.00	42.75(5% reduction)	40.50 (10% reduction)
Annual revenue	607500	577.125	546.750
Annual cost	533.878	553.878	553.878
A W	53.622	23.247	- 7.128.

Deductions

The project is very sensitive to price

A decrease in price of 10% would reduce the IRR to less than 15% (AW<0)

The investor would need to study the price structure of palm oil in the area, especially with the possible effect of increased competition. If the study reveals price instability the plant could be a risky investment.

Sensitivity to Useful Life

Assumption:

- Reduction in useful life of plant to 5 years
- Salvage valued remains constant

The only factor in that would be changed would be the cost of capital recovery.

Capital recovery

Plant $100,000(A\P, 15%,5)

- 20,000(A\F, 15%,5) = $26,866 per year

	Initial value	**New value**	**Amount of change**
Capital recovery (plant)	$18,940	26,866	+7926 (+41.85%)
Annual worth	53622	45.696	-7926 (- 14.78%)

Deductions

- A 50% reduction in useful life causes only 14.78% reduction in annual worth
- The venture is insensitive to the assumed useful life.

4. CONCLUSION

Basic engineering economy methods for project evaluation are highlighted. With the added information from the sensitivity analysis the investor would be better informed about critical factor and therefore could take appropriate actions.

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