Profitability Alternative Investment and Replacement

Process Engineering Economics

Profit and Profitability?

Profit is an absolute number determined by the amount of income or revenue above and beyond the costs or expenses a company incurs. It is calculated as total revenue minus total expenses and appears on a company's income statement. No matter the size or scope of the business or the industry in which it operates, a company's objective is always to make a profit.

Profitability is closely related to profit – but with one key difference. While profit is an absolute amount, profitability is a relative one. It is the metric used to determine the scope of a company's profit in relation to the size of the business. Profitability is a measurement of efficiency – and ultimately its success or failure. A further definition of profitability is a business's ability to produce a return on an investment based on its resources in comparison with an alternative investment.

Although a company can realize a profit, this does not necessarily mean that the company is profitable.

Alternative Investment

An alternative investment is a financial asset that does not fall into one of the conventional investment categories. Conventional categories include stocks, bonds, and cash. Most alternative investment assets are held by institutional investors or accredited, high-net-worth individuals because of their complex nature, lack of regulation, and degree of risk.

The final decision as to the best among alternative investments is simplified if it is recognized that each dollar of additional investment should yield an adequate rate of return. In practical situations, there are usually a limited number of choices, and the alternatives must be compared on the basis of incremental increases in the necessary capital investment.

A general rule for making comparisons of alternative investments can be stated as follows: *The minimum investment which will give the necessary functional results and the required rate of return should always be accepted unless there is a specific reason for accepting an alternative investment requiring more initial capital.*

EXAMPLE

The following simple example illustrates the principle of investment comparison. A chemical company is considering adding a new production unit which will require a total investment of $1,200,000 and will yield an annual profit of $240,000. An alternative addition has been proposed requiring an investment of $2 million and yielding an annual profit of $300,000. Although both of these proposals are based on reliable estimates, the company executives feel that other equally sound investments can be made with at least a 14 percent annual rate of return. Therefore, the minimum rate of return required for the new investment is 14 percent.

Replacements

The term “replacement,” as used in this chapter, refers to a special type of alternative in which facilities are currently in existence and it may be desirable to replace these facilities with different ones. Although intangible factors may have a strong influence on decisions relative to replacements, the design engineer must understand the tangible economic implications when a recommendation is made as to whether or not existing equipment or facilities should be replaced. The reasons for making replacements can be divided into two general classes, as follows:

1. An existing property must be replaced or changed in order to continue operation and meet the required demands for service or production. Some examples of reasons for this type of necessary replacement are:

a. The property is worn out and can give no further useful service.

b. The property does not have sufficient capacity to meet the demand placed upon it.

c. Operation of the property is no longer economically feasible because changes in design or product requirements have caused the property to become obsolete.

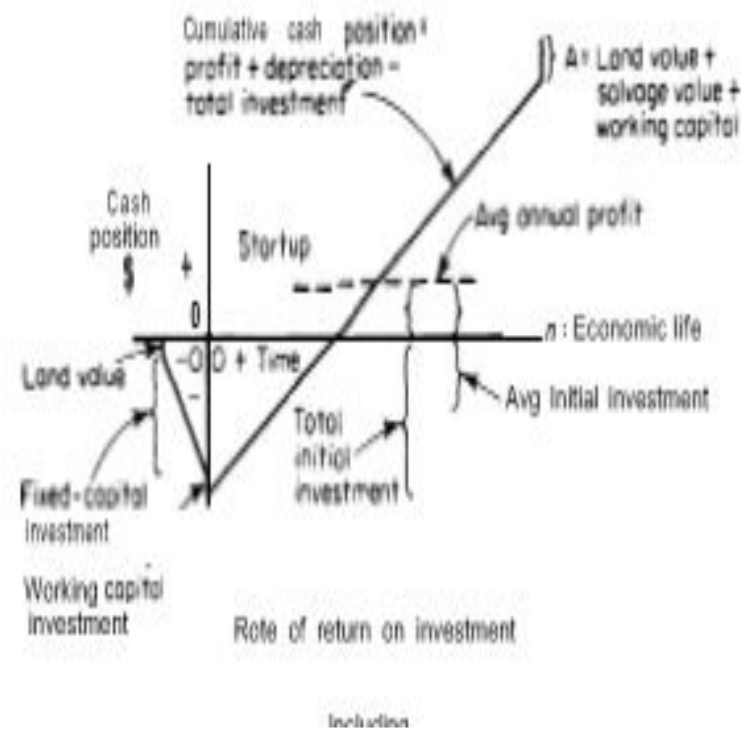
2. An existing property is capable of yielding the necessary product or service, but more efficient equipment or property is available which can operate with lower expenses.

When the reason for a replacement falls in the first general type, the only alternatives are to make the necessary changes or else go out of business. Under these conditions, the final economic analysis is usually reduced to a comparison of alternative investments.

Methods for Profitability Evaluation

1. Rate of return on investment
2. Discounted cash flow based on Internal rate of return
3. Net present value
4. Capitalized costs
5. Payback period

Rate of return on investment



In engineering economic studies, rate of return on investment is ordinarily expressed on an annual percentage basis. The yearly profit divided by the total initial investment necessary represents the fractional return, and this fraction times 100 is the standard percent return on investment.

Rate of return on investment

The ratio of profit expected from an investment project and the proposed investment for the project is called Return on Investment (ROI).

So we may write,

$$\text{ROI} = \frac{\text{amount of profit}}{\text{amount of investment}}$$

This ROI ratio is used as a criterion for the evaluation of an investment project. The greater the ROI of a project, the greater is its acceptability. There are three concepts about the amount of investment on a project. The amount of investment may mean the amount of assets, amount of capital invested, or the amount of equity capital. We may obtain three types of ROI on the basis of these three concepts.

(i) Return on Assets (ROA):

By definition, ROA is the ratio between net profit and the assets. We may write, therefore,

$$\text{ROA} = \frac{\text{net profit excluding taxes}}{\text{total assets}} \quad (20.28)$$

Here net profit does not include the interest to be paid to the lenders. But, since interest is included in the real return on total assets, an improved form of ROA is

$$\text{ROA} = \frac{\text{net profit excluding taxes} + \text{interest paid}}{\text{total assets}} \quad (20.29)$$

(ii) Return on Capital Employed (ROCE):

ROCE is the second type of ROI. Here net profit, excluding tax, is expressed as a ratio of the total amount of invested capital. The total amount of capital provided by the owner of the firm and the lenders is the total invested capital in this case.

We may have this estimate of capital in two ways.

First, the total amount of invested capital is the sum total of long-term liabilities and equity of the shareholders.

Second, invested capital is the summation of the net circulating capital and fixed assets.

Therefore, we may write here

$$\text{ROCE} = \frac{\text{net profit minus tax}}{\textit{total investment capital}} \quad (20.30)$$

Again, we may include the interest paid in net profit and write

$$ROCE = \frac{\text{net profit minus tax} + \text{interest paid}}{\text{total invested capital}} \quad (20.31)$$

(iii) Return on Shareholders' Equity (ROSE):

By definition, a general estimate of ROSE is

$$\text{ROSE} = \frac{\text{net profit minus tax}}{\text{total equity of the shareholders}} \quad (20.32)$$

Now the shares of a company may be of two types: preference shares and ordinary shares. Here, if the shares are ordinary shares, then we may write

$$\text{ROSE} = \frac{\text{net profit minus tax} - \text{dividend paid to preference shareholders}}{\text{equity of the ordinary shareholders}} \quad (20.33)$$

Payback Period

If an investment project is implemented, then the time or the number of years within which the summation of the flow of undiscounted net revenues becomes equal to the total cost of the project is called the payback period.
According to this method, if one of a number of projects is to be selected, then the project for which the payback period is minimum, should be implemented.
To illustrate the point let us take help of an example. Let us suppose that the expected flows of net revenue from two different projects and the costs of these projects are given in the table below.

Expected Net Revenue from the Investment Projects

Project	Initial cost	Net Revenue (Rs)					Payback period (years)
		First year	Second year	Third year	Fourth year	Fifth year	
I	2000	1000	1000	2000	2,500	3,000	2
II	2000	500	500	1000	8,000	10,000	3

From the data given above we see that in the case of project I, the sum total of the net revenue flow in the first two years has been equal to the project cost and, in the case of project II, the sum total of the net revenue flow in the first three years has been equal to the project cost.

In other words, the payback period for the two projects are 2 and 3 years, respectively. According to the payback method, if one of the two projects are to be implemented then the project I should be selected for implementation, for the payback period of this project is shorter than project II

Payout period, or payout time is defined as the minimum length of time theoretically necessary to recover the original capital investment in the form of cash flow to the project based on total income minus all costs except depreciation. Generally, for this method, original capital investment means only the original, depreciable, fixed-capital investment, and interest effects are neglected. Thus,

$$\text{Payout period in years (no interest charge)} = \frac{\text{depreciable fixed-capital investment}}{\text{avg profit/yr} + \text{avg depreciation/yr}}$$

Another approach to payout period takes the time value of money into consideration and is designated as payout period including interest. With this method, an appropriate interest rate is chosen representing the minimum acceptable rate of return.

The time to recover the tied-capital investment plus compounded interest on the total capital investment during the estimated life by means of the average annual cash flow is the payout period including interest, or Payout period including interest.

$$= \frac{\text{depreciable fixed-capital investment} + \text{interest on total capital investment during estimated service life}}{(\text{avg profit/yr} + \text{avg depreciation/yr})_{\text{as constant annuity}}}$$

This method tends to increase the payout period above that found with no interest charge and reflects advantages for projects that earn most of their profits during the early years of the service life.

Capitalized Cost

The capitalized-cost profitability concept is useful for comparing alternatives which exist as possible investment choices within a single overall project. For example, if a decision based on profitability analysis were to be made as to whether stainless steel or mild steel should be used in a chemical reactor as one part of a chemical plant, capitalized-cost comparison would be a useful and appropriate approach. Capitalized cost related to investment represents the amount of money that must be available initially to purchase the equipment and simultaneously provide sufficient funds for interest accumulation to permit perpetual replacement of the equipment. If only one portion of an overall process to accomplish a set objective is involved and operating costs do not vary, then the alternative giving the least capitalized cost would be the desirable economic choice. The basic equation for capitalized cost for equipment can be written as follows:

$$K = C_V + \frac{C_R}{(1+i)^n - 1} = \frac{C_R(1+i)^n}{(1+i)^n - 1} + V_s$$

where K = capitalized cost
C_V = original cost of equipment
C_R = replacement cost
V_s = salvage value at end of estimated useful life
n = estimated useful life of equipment
i = interest rate

$$\frac{(1+i)^n}{(1+i)^n - 1} = \text{capitalized-cost factor}$$

Net present Value

Definition of NPV:

Let us suppose that from some investment project the firm expects to obtain net revenues of R] in the 1st year, R2 in the 2nd year,..., Rn in the nth year. Let us also suppose that the initial cost of the project is C0 and apart from this, the firm would have to spend on the project an amount of Q in the 1st year, C2 in the second year,..., Cn in the nth year.

If we now deduct the present value of the flow of costs of the project from the present value of the flow of net revenues, we would obtain the net present value (NPV) of the project.

In order to obtain the present values of the flows of revenue and cost, we shall use the rate of cost of capital (r) as the discount rate, and we shall assume that the revenue of a particular year would be obtained at the end of the year, and cost of any year should also be paid at the end of the year. Therefore, by definition, we obtain the net present value (NPV) for the project to be

$$\text{NPV} = \left[\frac{R_1}{1+r} + \frac{R_2}{(1+r)^2} + \ldots + \frac{R_n}{(1+r)^n}\right] - \left[C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_n}{(1+r)^n}\right]$$

$$= \sum_{t=1}^{n} \frac{R_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} \qquad (20.34)$$

$$= \sum_{t=1}^{n} \frac{R_t}{(1+r)^t} - C \qquad (20.34a)$$

where $C = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$.

We may note here that if we have $C_1 = C_2 = \ldots = C_n = 0$ then we would obtain $C = C_0$.

Internal Rate of Return Based on Discounted Cash Flow

Definition of IRR:

The Internal Rate of Return (IRR) is a rate of discount (m) that makes the present value of the expected revenues to be obtained from an investment project equal to the present value of the cost of the project.

Let us suppose that from an investment project with n years of life, the expected revenues to be obtained at the end of years 1,2……………… n are, respectively, $R_1, R_2, \ldots, R_n$. Let us also suppose that the initial cost of the project is C_0 and the costs to be incurred at the end of different years are $C_1, C_2, \ldots C_n$. Therefore, here the present value (PV) of the costs of the project would be

$$C = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

Here the rate of discount r is equal to the rate of cost of capital.

Now, the IRR, according to definition, would be obtained from the equation:

$$C = \frac{R_1}{1+m} + \frac{R_2}{(1+m)^2} + \ldots + \frac{R_n}{(1+m)^n}$$

$$\text{or, } C = \sum_{t=1}^{n} \frac{R_t}{(1+m)^t}$$

Here m is such a rate of discount that would make the sum total of the present values of R_1, R_2,...., R_n, equal to C. Therefore, by definition, m is the internal rate of return of the project. This IRR has been called by Keynes the marginal efficiency of capital.

We may easily understand why m is called the IRR. For the implementation of the project, the firm spends at present a sum of money equal to C. In equation (20.37), we see that spending a sum of money equal to C means simultaneous spending of the sums $R_1/1 + m$, $R_2/(1+m)^2$ .... $R_n/(1+m)^n$.

Now, the firm spends $R_1/1+m$ of money at present and it (expectedly) recovers R_1 of money at the end of the first year—here the rate of return is m which is equal to the rate of discount.

Again, the firm spends $R_2/(1+m)^2$ of money at present and it recovers R_2 of money at the end of the second year, the rate of return being again m. Proceeding in this way, ultimately we see that the firm spends $R_n/(1+m)^n$ of money at present and recovers R_n of money at the end of the nth year, the rate of return being again m.

Therefore, what we have seen is that the firm spends at present an amount of money C on the project and earns a rate of return m on each and every portion of this investment. That is why m is called the internal rate of return or average rate of return.

What Is the Time Value of Money (TVM)?

The time value of money (TVM) is the concept that money available at the present time is worth more than the identical sum in the future due to its potential earning capacity. This core principle of finance holds that provided money can earn interest,

Depending on the exact situation in question, the time value of money formula may change slightly. For example, in the case of annuity or perpetuity payments, the generalized formula has additional or less factors. But in general, the most fundamental TVM formula takes into account the following variables:

- FV = Future value of money
- PV = Present value of money
- i = interest rate
- n = number of compounding periods per year
- t = number of years

Based on these variables, the formula for TVM is:

$$FV = PV \times [\, 1 + (i / n) \,]^{(n \times t)}$$

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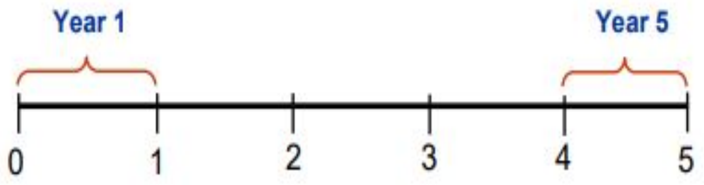
Cash Flow Diagram: The Basic Concept

Cash Flow Diagrams

- A cash flow diagram is simply a graphical representation of cash flows (in vertical direction) on a time scale (in horizontal direction). Time zero is considered to be present, and time 1 is the end of time period 1.

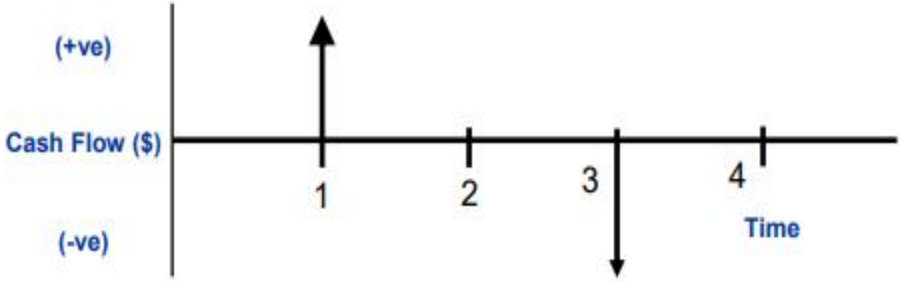
- This cash flow diagram is set up for five years.



Cash Flow Diagrams

- The direction of the cash flows (income or outgo) is indicated by the direction of the arrows.

- From the investor's point of view, the borrowed funds are cash flows entering the system, while the debt repayments are cash flows leaving the system.

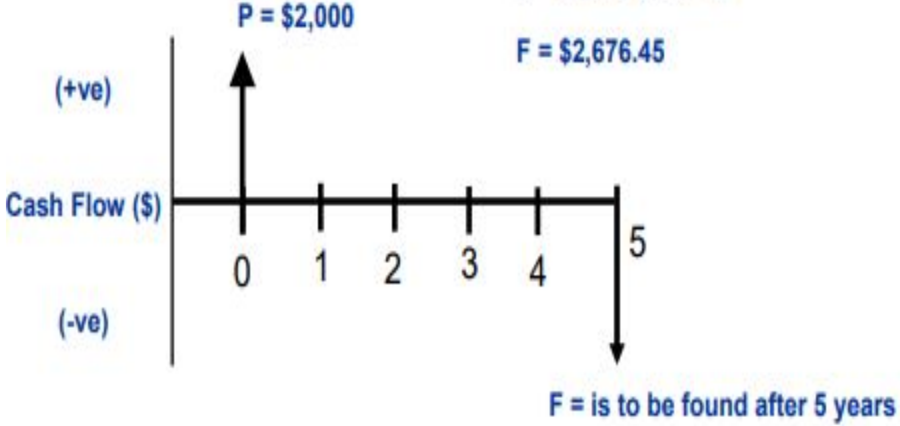


Cash Flow Diagrams

- Example 1: If you borrow $2,000 now and must repay the loan plus interest (at rate of 6% per year) after five years. Draw the cash flow diagram. What is the total amount you must pay?

$F = \$2,000\ (1+0.06)^5$

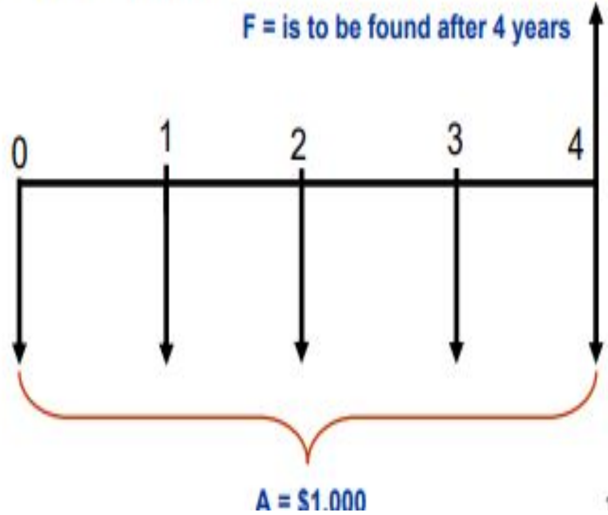
$F = \$2,676.45$



Cash Flow Diagrams

- Example 2: If you start now and make five deposits of $1,000 per year (A) in a 7% per year account, how much money will be accumulated immediately after you have made the last deposit. Draw the cash flow diagram. What is the total amount you will accumulate?

Since you have decided to start now, the first deposit is at year zero and the fifth deposit and withdrawal occur at end of year 4



Symbols and Cash Flow Diagrams

- The mathematical relations used in engineering economy employ the following symbols:

Note:

The dollar amount of F and A are considered at the end of the interest period.

P = Value of sum of money at a time denoted as the present.

F = Value or sum of money at some future time, or a single sum of money at the end of n interest period.

A = A series of periodic, equal amount of money.

n = Number of interest periods.

i = Interest rate per interest period.

Cash Flow

- Every person or company has cash receipts (income) and cash disbursement (costs).
- The results of income and costs is called cash flow.

Cash Flow = Receipts – Disbursements

- A positive cash flow indicates a net receipts in a particular interest period or year.
- A negative cash flow indicates a net disbursement in that period.

Cash Flow

- Example: If you buy a printer in 1999 for $300, maintain it for three years at a cost of $20 per year, and then sell it for $50, what are your cash flows for each year?

Year	Receipts	Disbursement	Cash Flow
1999	0	$300	- $300
2000	0	$20	- $20
2001	0	$20	- $20
2002	$50	$20	+ $30

- Its important to remember that all receipts and disbursements and thus cash flows are assumed to be end-of period amounts. Therefore, 1999 is the present (now) and 2002 is the end of year 3.

Cash Flow

- Example: Suppose you borrowed $1,000 on May 1, 1984, and agree to repay the loan in one lump sum of $1,402.60 at the end of four years at 7%. Tabulate the cash flows?

Date	Receipts	Disbursement	Cash Flow
May 1, 1984	$1,000	0	+ $1,000
May 1, 1985	0	0	0
May 1, 1986	0	0	0
May 1, 1987	0	0	0
May 1, 1988	0	$1,402.60	- $1,402.60