Evaluation Techniques

This lesson will focus on two important areas:

1. Evaluation techniques for common operating issues that arise in facilities
2. Firm-wide capital budgeting

Most engineers who are associated with operating facilities are faced with decisions about replacement of equipment or abandonment of equipment from time to time.

Replacement decisions are called defender/challenger studies where the existing unit is the defender and the proposed (or new) unit is the challenger.

Evaluation Techniques: Delay of Projects

We know that the Present Worth of a project is the cashflow value of the excess return over the MARR at a point in time. A typical question for project managers is what is the effect of acceleration or delay in the project schedule? What happens if the project does not start until, say, one year later?

The answer to these types of questions is usually formed by calculating the change in Present Worth over the time interval of the delay. For instance, accelerating a project by one year permits us to generate revenues one year earlier and therefore generate positive cashflows one year sooner which increases the present worth of the project. Conversely, delay of one year would cause a decrease in present worth by deferring positive cashflows by one year. The difference in present worth's over the period is the effect of the delay or acceleration.

A significant assumption is the issue of whether the project life will shift intact based on the delay or whether there is reason to believe that a truncation of cashflows would occur at the end of the project life. In my experience, when using a 15 or 20 year project life, the analyst will assume a shift of cashflows with an intact project life instead of assuming a truncation. It would be unusual if a "hard" termination date was known so far in advance. On the other hand, if a project life is three years and the revenues are controlled by a contractual obligation, then truncation would be a possible outcome and should be considered.

Example:

A manufacturing plant is under construction in Nebraska and its benefits are expected to be worth $15,000,000 when complete. It is expected to have a 20 year economic life.

Question:

If the owner uses MARR of 15%, what is it worth to speed up the construction so that it can open at the beginning of the next canning season rather than a year later?

Answer:

A set of cash flows equivalent to $15,000,000 at time zero (beginning of the next canning season) would undergo a one year shift delay unless the speedup occurs. From Figure 5.4 in the text, given P=$15,000,000, the present worth of avoiding the delay is:

$$P(1 - b) = \$15{,}000{,}000\ [1 - (1 / 1.15)] = \$1{,}960{,}000$$

It is worth nearly $2 million to speed up the construction.

You can see in the approach to evaluation that the analyst must consider all known business conditions upfront as part of the scenario, the remainder of the cashflow scenario is developed based on stated assumptions that are "common sense" for the project.

Evaluation Techniques: Annual Equivalent

The next evaluation technique applies to situations where the engineer must make economic decisions about alternatives in on-going manufacturing operations. The decisions require the use of time value of money when the decision effects are incurred over multi year periods and there are different capital costs and operating costs with each alternative.

The most significant factor in these types of scenarios is the repeatability of the actions and what is called a "vague horizon." This means that the alternatives can be considered to go on as long as the overall manufacturing operation continues. A typical example is the choice between catalysts for reactivation of a catalytic reactor. The catalyst change out has both capital cost impacts and operating cost impacts. The change out cycle occurs periodically depending on the catalyst selected. As long as the plant operates, the catalyst change outs will be required.

If we assume repeatability with no definite horizon, then each catalyst will have an Annual Equivalent cost. We will seek the catalyst with the lowest annual equivalent cost.

Example:

Ajax Chemical Company has a catalytic reactor that is expected to be operational for 8 years. Activation with catalyst A costs $7500 and will last 1.5 years before requiring reactivation. An alternative catalyst B will last 2.5 years before reactivation is required, and costs $10,000.

Question:

Assuming MARR is i_{eff} = 18%, which catalyst should be used?

Answer:

Assume repeatability, that is, the activations will all be done with the same catalyst at the same cost. Assume the 8 year life is vague, that is the life of the reactor is substantially longer than the economic life of any alternative, and the unused life of the catalyst on the abandonment of the reactor will be anything from zero to the alternative's life.

Use the annual equivalence technique to determine the annual worth of each alternative over its economic life:

A: $A = \$7500\ (i / (1-b)^n) = \$7500\ [.18 / (1 - (1 / 1.18))^{1.5}] =$ $6140/year

B: $A = \$10000\ (i / (1-b)^n) = \$10000\ [.18 / (1 - (1 / 1.18))^{2.5}] =$

$5310/year

B has the lower equivalent annual cost and therefore is the catalyst chosen.

In this example, the annual equivalent technique includes consideration of the capital cost of the catalyst alternatives and the alternative change out timing. A real example would also include changes to yields (revenues), operating costs, and differential installation costs, if any.

If the cases under consideration produce the same revenue, then the engineer would seek smallest annual equivalent costs as the best alternative. If changes to revenues are used to compute cashflows, then the engineer must seek the highest annual equivalent to maximize returns to the firm.

Evaluation Techniques: Explicit Salvage

In the previous example of annual equivalent, there was a vague horizon and repeatability was assumed. Beyond that horizon, no further cashflow impacts were considered. It is possible that significant salvage value effects could be present at the end of a typical operating period. If these effects can be estimated with some certainty, then they should be considered as a case. See the following example.

Example:

If Ajax's catalytic reactor were to be abandoned in 6 years, and the lives of the two alternative catalysts are exactly 1.5 and 2.5 years respectively.

Question:

Evaluate the two alternatives considering salvage value.

Let the present worth of the costs have an 18% interest rate.

Answer:

At 6 years, catalyst **A** will be "fully spent" and have no value. Catalyst **B** will be 1 year old and still have 1.5 years of remaining life. Assume a salvage value of S for catalyst **B**. Let C represent the present worth of the cost of each alternative.

$C = S\ A_t\ b^t$

$C^A = \$7500 + \$7500\ b^{1.5} + \$7500\ b^{3} + \$7500\ b^{4.5} = \$21450$

$C^B = \$10000 + \$10000\ b^{2.5} + \$10000\ b^{5} - S\ b^{6} = \$21000 - S\ b^{6}$

The advantage of **B** over **A** depends on the salvage for **B**.

For zero salvage value:

$C^A / C^B = \$21450 / \$21000 = 1.021$

This indicates an excess cost of **A** over **B** of 2.1%. Because after 6 years a time, at which catalyst **B** has considerable unused life already paid for, the advantage of **B** over **A** is considerably reduced.

Computing salvage value implied by the annual equivalence technique:

From the previous example:

$C^A / C^B = \$6140 / \$5310 = 1.156$

Therefore setting:

$\$21450 / \$21000 - S b^{6} = 1.156$

the salvage value implied by annual equivalence.

S = $6610

Evaluation Techniques: Optimal Abandonment

It is always a possibility that economic conditions will change and force a decision to close or abandon a facility. Oil well depletion, mine depletion, and other natural resource declines will eventually lead to an uneconomic attempt to continue extraction. These cases are within the normal scope of operating decisions in these types of businesses. Manufacturing facilities are subject to sales declines, revenue declines from price decreases, and obsolescence where further operation is uneconomic. The engineer is confronted with a decision based on determination of the conditions under which operation could continue or the appropriate shut down timing.

To determine shutdown timing, the engineer compares the returns from further operation with the salvage value (or liquidation value) of the business. If the return for the next period is less than the return that could be earned on the salvage value then it is appropriate to liquidate.

Example:

A crew works on a mine whose ore brings in $180,000 of revenue, at the end of each year. The cost of the crew and land taxes is $100,000 each year. When abandoned, the land can be restored and the land sold for $200,000 more than the cost of restoration.

Question:

Determine the (integer year) best time to abandon the mine and sell the land.

Answer:

I do not want you to be distracted from an important concept by wading through a lot of math. The table below provides the pertinent data to ascertain the correct answer.

Looking at cash flow we have revenue and salvage value that are positive and crew/land taxes which are negative. The table below summarizes are evaluation.

Years	**0**	**1**	**2**
Revenue	0	$131,000	$227,000

Cost	0	$91,000	$174,000
Salvage	$200,000	$182,000	$165,000
Total Present Worth	$200,000	$222,000	$218,000

After the first year the total present worth starts to decline. Therefore, this is the optimal time to abandon the mine.

The differential criterion for abandonment is to operate until the next period's returns do not offset the delay and decrease the salvage value.

In following this principle, the engineer must take into account all cashflow consequences post-liquidation in determining salvage value. We normally think of liquidation as producing a positive cashflow; however, a shut down can trigger unemployment compensation, payoff of unfunded pension liabilities, environmental liabilities for facility closure, clean-up, and remediation, and many other "hidden costs." Abandonment of facilities is a process that entails lots of studies and consideration of alternatives prior to a final commitment.

Evaluation Techniques: Defender/Challenger Studies

As equipment wears out, new technologies are implemented, and changes to manufacturing flexibility are required, engineers are asked to compare the existing equipment with new versions of machines and systems. Should we run the existing gear or replace it with new equipment? This decision is the comparison of at least two alternatives. The first alternative is to run the existing equipment for a selected period of time (project life). This is the base case which is sometimes called the "defender." The alternative is to replace the existing equipment with "new" equipment and systems that are an improvement over the base case. What should you be asking yourself? Is the new equipment and/or system beneficial enough to pay for the additional capital cost at the firm's required return?

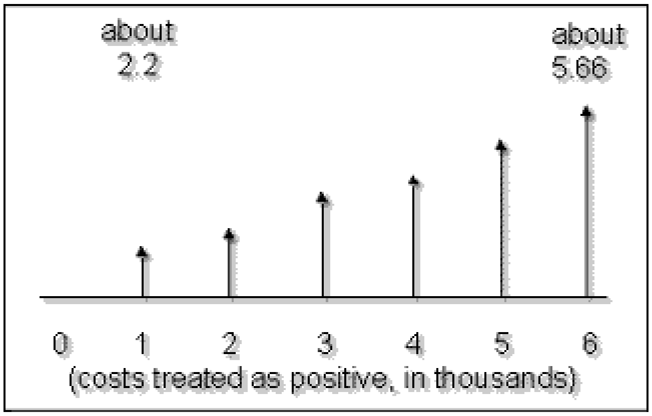
The engineer can set up this case study by estimating the costs of the new system, the salvage value of the old system, and the changes to revenues and costs with the new system versus the old system. Next, the engineer would construct the cashflow diagram for the replacement action. If the present worth of the replacement action is positive at the firms' MARR then replacement is warranted.

Example:

A process plant undergoes a maintenance shutdown once per year. Cooling coils are replaced by cleaned ones when observed to be appreciably clogged by scale buildup on their inside walls. Clogging increases power consumption in pumping cooling water through the coils; the indexed annual pumping costs are estimated to obey the growth curve

$$X_q = 81.5\ (8 - 0.6\ q)^{-1.8}$$

where X_q is the annual pumping cost in thousands of dollars when the set of coils is q years "old" at the end of the year.



Question:

The plant uses a real annual interest rate of 12%. If a replacement has an indexed cost of 4 (that is, $4000), including the worth of the cost of descaling the replaced coils for future reuse, determine the best age at which to replace clogged coils.

Answer:

From equation 5-21 in the text, for b = 1 / 1.12 and a replacement age t, we have

$$-P_1^t = 4 + S^{t}_{q=1}\, 81.5\,(8- 0.6\, q)^{-1.8}\, b^q$$

And from equation 5-23 in the text, for d = 0.12, we have

$$-A^{(t)} = -P_1^{(t)} \{d / 1-b^t\}$$

Using these equations determine the replacement age that minimizes $-A^{(t)}$:

t	1	2	3	4	5	6	7
$-P_1^{(t)}$	5.983	8.045	10.218	12.549	15.012	17.970	21.304
$-A^{(t)}$	6.701	4.760	4.254	4.132	4.189	4.371	4.668

The annual equivalent is minimum when t = 4 years.

Capital Budgeting

Up to this point in the course, we have been developing tools and techniques for consideration of business decisions in technical organizations on a project by project basis. Throughout your firm there are numerous projects based on needs for facility additions, improvements, upgrades, etc. Each of these items requires capital from the firm for implementation. How does the firm decide which opportunities to implement? What are the methods of making decisions to protect the financial soundness of the firm? Why is this important?

First of all, firms that invest well, make good returns on capital. This translates into increasing earnings and stock prices. These growing companies are good to work for because you can get raises and promotions. There is usually a direct link between the growth of the firm you work for and your own growth opportunities.

All firms have the need for a system of financial controls that insures as much as possible that investment capital flows to the projects with the best returns. This is the motivation for a capital budgeting decision system which allocates capital to meet the requirements for growth while insuring that the projects payback their cost of capital and risk premium return.

There are generally three sources of investment capital for a firm including:

1. Retained earnings (this is after tax income)
2. Depreciation
3. External finance in the form of bank loans, bonds, or stock

The first two sources are under the control of management and do not require external activity. The last source requires dealing with commercial banks, investment banks, and investors. We will review these areas in more detail in the follow-on courses ENMGT 535 Financial Management I and ENMGT 536 Financial Management II.

Evaluation Techniques: Independent Projects

For consideration of capital budget decisions, projects are set forth and analyzed so that the consequences are independent; therefore, the calculated returns are for the independent project(s). Dependent projects should be grouped and reanalyzed as one decision with sub optimization within the group to avoid mistakes.

The process is quite simple. All projects available to the firm are identified by capital cost and Present Worth at MARR then listed in order of increasing investment. For a simple list, (that is, short enough to use visual inspection), the total capital required is compared with the available capital. If there is sufficient capital for all projects then all should proceed. This is rarely the case. It is management's obligation to find and propose as many new projects as possible that can increase the worth of the firm. Usually, there is a capital shortage when there are many more projects than capital to fund them. In this case, the combination of projects that lead to the highest increase in present worth is the proper combination.

Example:

A company's board has not decided what its investment budget will be for the coming fiscal year. Besides many opportunities to invest various amounts in the ordinary course of business at a rate of return of about 15%, there are these extraordinary opportunities (independent of each other, in thousands of dollars):

Project	Required Investment	Net Present Worth at *i=15%*
1	30	26
2	40	30
3	90	100

Question:

Determine the corresponding set of mutually exclusive alternatives, and for each give its required investment and its present worth.

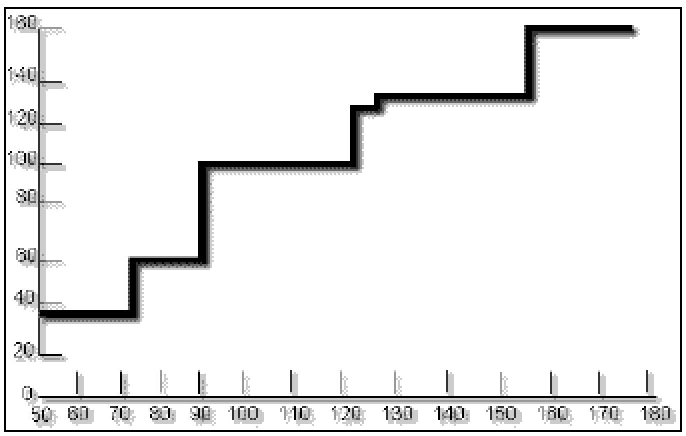
Answer:

Each alternative is a combination of independent opportunities, and has a required investment equal to the sum of their required investments and a present worth equal to the sum of their present worth's (in thousands of dollars):

Alternative	Required Investment	Present Worth
0	0	0

1	30	26
2	40	30
3	90	100
1, 2	70	56
1, 3	120	126
2, 3	130	130
1, 2, 3	160	156

The set of mutually exclusive alternatives corresponding to a set of independent opportunities typically exhibits *diminishing returns* in that an increase to a small investment budget earns more worth increase than the same increase to a larger budget.



In a large firm, the number of opportunities is significant and the exhaustive enumeration of the opportunities is prohibitive. Two additional methods are used in practice to prioritize capital budget requests - NPVI ordering and IRR (ROR) ordering.

Capital Budgeting: NPVI Ordering

In assessing capital opportunities, we need to measure the potential reward versus the size of the initial investment. This ratio of Present Worth divided by Investment is the "Net Present Value Index," also called the "Investment Efficiency." We would generally prefer projects with higher investment efficiency because the potential returns are higher per increment of investment. To perform this review, we compute the NPVI for each project then rank the list by decreasing NPVI, selecting projects from top to bottom up to the available capital.

Example:

Four independent projects are contending for an investment budget of 30 (all amounts in thousands of dollars):

Project j	P_j	I_j
1	52	22
2	42	14
3	15	8
4	12	6

The optimal alternative is to accept projects 2, 3, and 4, earning a present worth of 69 for an investment of 28. Apply NPVI ordering.

Question:

Does it give the optimal solution?

Answer:

$P_1 / I_1 = 2.3636$

$P_2 / I_2 = 3$

$P_3 / I_3 = 1.8750$

$P_4 / I_4 = 2$

Sorting the P_j / I_j values in decreasing order, the opportunities should be considered in the order 2,1,4,3.

Accept Project 2, leaving an unused budget of 30-14 = 16.

Consider Project 1, which is infeasible because I_1 >16.

Accept Project 4, leaving an unused budget of 16 - 6 = 10.

Accept Project 3, leaving an unused budget of 10 - 8 = 2.

This procedure accepts Projects 2, 3, and 4, which is the same as the optimal solution.

The NPVI procedure is a "rule of thumb" that works in most cases to select a set of projects close to the optimal; however, it can fail to identify the optimal solution in certain cases. Please Read example E6 p282 in the text.

Another rule for ranking projects is IRR (ROR) ordering.

Capital Budgeting: ROR Ordering

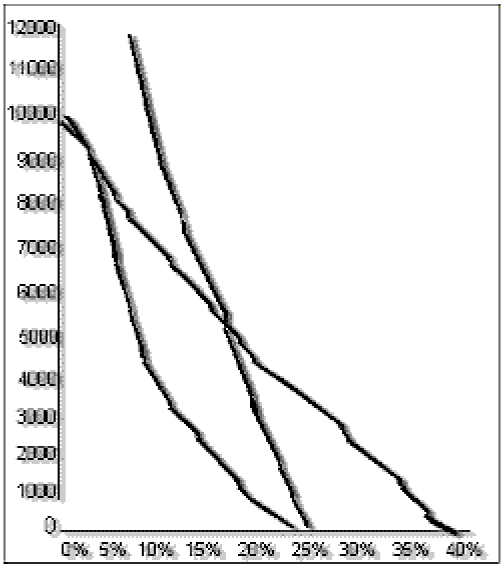
Another "rule of thumb" is to rank order the list of capital opportunities from highest IRR (rate of return) to lowest IRR, and accept projects up to the level of capital availability. This very common procedure is applied as follows:

Example:

The projects shown in the following graphics are independent opportunities available to a decision maker who has a capital budget of $10,000. Consider two separate cases: the ordinary course of business yields a 12% rate of return, or the ordinary course of business yields an 18% rate of return.

Question:

For each of the cases, determine the set of projects to be recommended by ROR-ordering procedure, the set recommended by the NPVI-ordering procedure, and the optimal set.



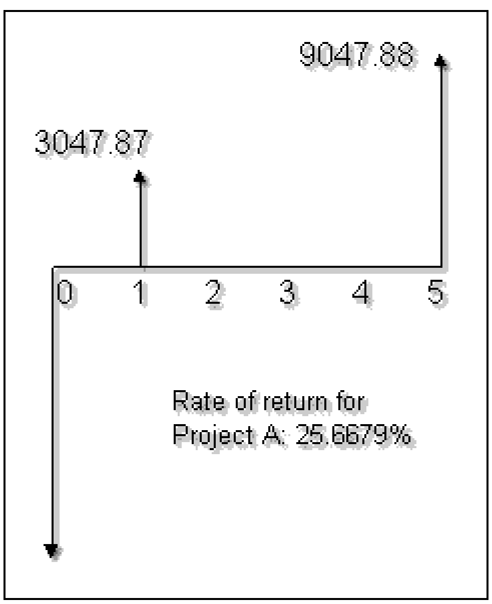
Note: (Left to Right at values below $4000)

Leftmost curve : Project A

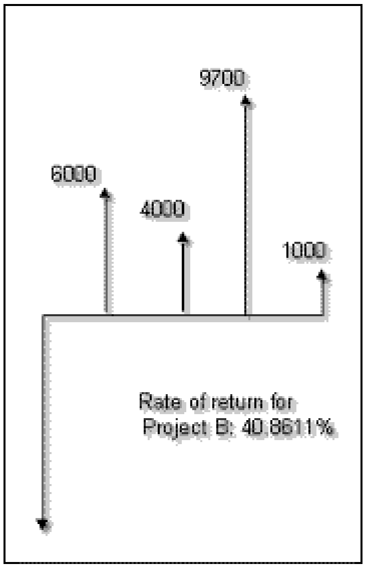
Center curve : Project C

Rightmost curve : Project B

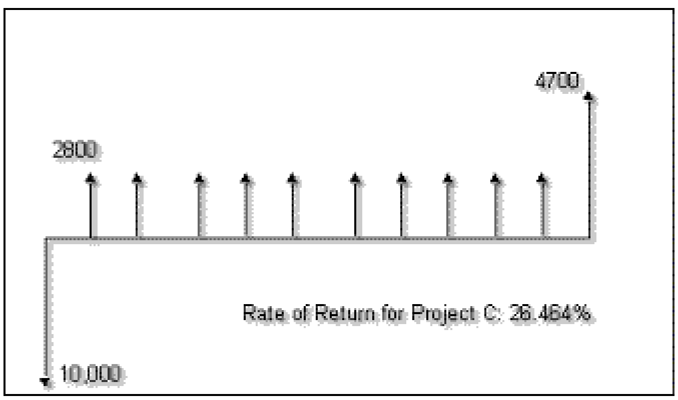
Project A



Project B



Project C



Answer:

Case 1 : MARR = 12%

From the graphics, the projects sorted in decreasing ROR order are **B**,

C and **A**. Since they each require a $10,000 investment and the budget is $10,000, the **ROR-ordering procedure recommends B.**

Since it is clear that $P^{(\mathbf{C})} > P^{(\mathbf{B})}$ at 12% interest, and
$NPVI^{(\mathbf{C})} = P^{(\mathbf{C})}/10{,}000$ is greater than
$NPVI^{(\mathbf{B})} = P^{(\mathbf{B})}/10{,}000$, the **NPVI-ordering procedure recommends C.**

The optimal set is obviously **C**. At 12% interest, with ß = 1/1.12, the present worth is

$P^{(\mathbf{C})}$ = -10,000 + 2800 (P/A 12%, 10) + 4700 $ß^{11}$ = **$7171.76**

The present worth of **B** at 12% is

$P^{(\mathbf{B})}$ = -10,000 + 6000 ß + 4000 $ß^2$ + 9700 $ß^3$ + 1000 $ß^4$ = **$6085.70**

Using the ROR-ordering procedure would cause a wrong decision that reduces the present worth by $1086.06.

Case 2 : MARR = 18%

The ROR-ordering procedure, which ignores MARR, recommends **B** as before. It is clear that $P^{(\mathbf{B})} > P^{(\mathbf{C})}$ at 18% interest, and $NPVI^{(\mathbf{B})} = P^{(\mathbf{B})}/10{,}000$ is greater than $NPVI^{(\mathbf{C})} = P^{(\mathbf{C})}/10{,}000$; hence the **NPVI-ordering procedure recommends B.**

The optimal set is obviously **B**. At 18% interest, with ß=1 / 1.18, the present worth is

P(**B**) = -10,000 + 6000 ß + 4000 $ß^2$ + 9700 $ß^3$ + 1000 $ß^4$ = **$4376.99**

This example (E7) has shown that ROR-ordering does not necessarily fill a budget in the most profitable way. Comparing **B** and **C**, we note that **B** *returns less money faster, while* **C** *returns more money slower.* This causes **B** to have a greater ROR and to be better for a high-MARR impatient investor, while **C** is better for a low-MARR patient investor.

Both NPVI ordering and IRR (ROR) ordering are methods of approaching an optimal capital budget solution in "non-ideal" world. The range of variation (that is, errors!) in estimates of the future in project economics is usually larger than the impact of the sub-optimization effect of using the rules of thumb for selection ranking.

The difference in project selection from NPVI ordering versus ROR (IRR) ordering is derived from the underlying assumption in computing IRR versus present worth. When IRR is computed, the implicit assumption is that the cashflows are "reinvested" by the firm at the IRR (this is generally not true). This is different than present worth which assumes a "reinvestment" rate of the MARR. The IRR method will tend to favor small projects with very high returns and will favor projects with near term cashflows. This is not necessarily bad, but a series of small high return projects should not necessarily "drive out" one larger project with a good return. This area of capital budget decision making is linked to strategic planning and the growth cycle of businesses which we will cover in a later course.

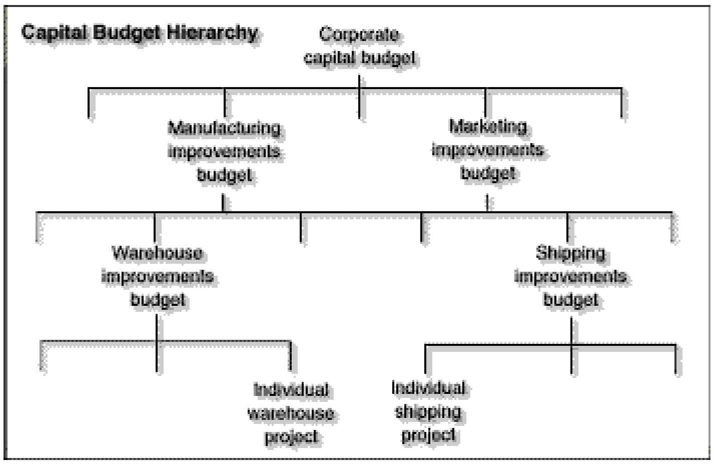
The capital budgeting process must select projects which maximize the worth of the firm over time. Identification of independent opportunities and ranking by NPVI and IRR are methods to guide the selection process.

Management Systems for Capital Control

In large multi-location, multi-plant firms, the capital budget system allocates capital to locations based on proposed projects and normal requirements for capital upgrade work. The individual projects by site are reviewed at various levels of management depending on the amount of capital required with larger amounts requiring higher level approvals. It is the function of the firm's financial controls group to administer the requests for capital and insure that they comply with the evaluation criteria established for the appropriate level of capital commitment.

Common tools used to check for appropriate returns include: Payback, Present Worth, IRR, and NPVI. These should be computed and set forth in a capital justification document that describes the request and project, documents the business assumptions, and shows that the project meets the firms return requirements. A summary signature page on the front of this request document shows that it has been reviewed and approved at the appropriate levels.

The firm can manage its capital budget requirements by allocating a "pool" of funds to each business area. Projects are developed and approved during the year and funded from this allocated "pool." An alternative (or complementary) method that management can use to manage the capital budget is to raise or lower the MARR.



MARR: Facts and Politics

MARR is the required minimal rate of return to protect the financial soundness of the firm. It is set by the management of the firm and is adjusted from time to time to take into account changes in business and financial conditions. It is not the cost of capital to the firm; however, the cost of capital is a component of MARR.

A simple view of the MARR is that it is comprised of 1) the cost of capital to the firm plus 2) an appropriate "risk premium" to account for over optimistic estimates and inherent business risk in the firms line of business. So if the cost of capital is, say, 10% then the MARR would be set at, say, 15% where the 5% increment represents the "risk premium."

The management of the firm usually uses a "post-audit" approach to see how well projects have worked out relative to the projected returns. Sadly, most project returns are overly optimistic. This "look back" process helps management keep the MARR adjusted to make sure that the cost of capital is covered.

The process of adjusting MARR is called "tuning" and is usually done based on year of year assessments of the capital budget required for the business and other external factors. A typical goal is to set the MARR high enough that the firm must rigorously develop and assess good opportunities and force rank them to allocate capital as a scarce resource. If MARR is too low, too much capital can be requested and approved leading to lower firm-wide returns.

Basic rule for establishing MARR:

Set MARR so that the screened, refined investment proposals (that are expected to perform better than the ordinary course of business) collectively demand capital or other investment resources at approximately the level available.

The management of the firm keeps an eye on many factors in setting MARR. These include:

- Inflation
- Risk
- Cost of Capital
- Optimism, advocacy bias
- Taxes
- Non-monetary considerations-broad goals, public relations, social concern, etc.
- Liquidity, cash management

Remembering our view that MARR is the cost of capital plus a risk premium, let's take a look at these one by one.

Inflation - The perception of inflation raises the cost of capital because investors require a real return on investment after inflation and taxes. As inflation rises, long bond yields rise, debt is more costly and the cost of capital is increased. MARR rises with inflation.

Risk - There are two components to risk, 1) cost of capital component from external perception of business risk (investors require a higher return from higher risk businesses) and 2) the firm's internal perception of risk which sets the risk premium.

Cost of Capital - Other than inflation, and external perception of risk, the cost of capital also depends on the mix of bank debt, bonds, and stock. The relative proportion of these in relation to the firms operating cashflow and assets changes the cost of capital.

Optimism, and advocacy bias - This is internal to the firm and is part of the "risk premium."

Taxes - Higher taxes cause investors to require higher returns and raise the cost of capital which raises MARR. This dampens investment and slows growth. Lower taxes have the opposite effect. Investment tax credits have a marginal effect in increasing investment. Changes to depreciation schedules such as raising allowable write-off periods reduce (slows) investment.

Non-monetary considerations - If a firm faces substantial environmental liabilities which must be funded to continue as a "going concern," then capital for profit producing projects will be severely restricted effectively raising the MARR substantially.

Liquidity, Cash Management - Although there is no "a priori" connection between short term cash management and long term asset finance, financial operations have to be timed to provide the funds for major projects so that new opportunities are not "kept waiting" while the financing is obtained. This kind of "friction" in obtaining and applying funds does raise the perception of risk and can have an impact on raising MARR.

Hopefully, this review of MARR has given you a new perspective on the inner workings of capital allocation in a firm and the linkages to the external world of investors. The MARR is a way of linking the investment requirements at the project level with the ability to pay for those investments.

Successful firms manage this process as part of their on-going efforts to grow and thrive. As you can see, engineers participate in providing the information and analyses necessary to justify new investment assuming that growing the firm will lead to financial success.

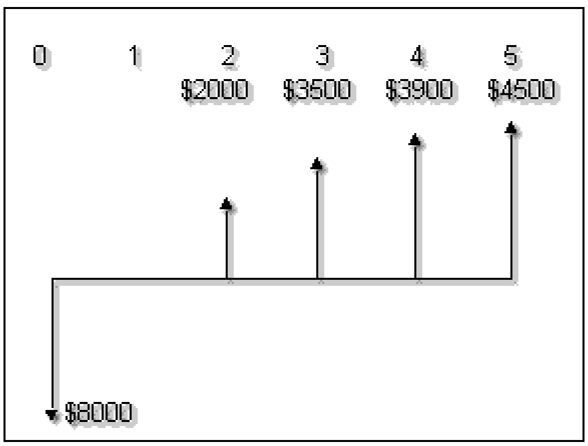
Use of Leverage

As we saw in the last section, the MARR is higher than the cost of capital. If the firm has many projects that produce superior returns, then the firm can "borrow" money from investors and reap the "excess" return over the cost of capital (from the investors). This is the concept of leverage. You borrow money to fund part of a project so that "frees up" your own investment capital for other opportunities.

The following is an example of this concept.

Example:

For our sawmill we want to purchase a special saw to increase our furniture production capacity. The saw will cost $8000. Our MARR is 10%. We have the following expected cash flow:



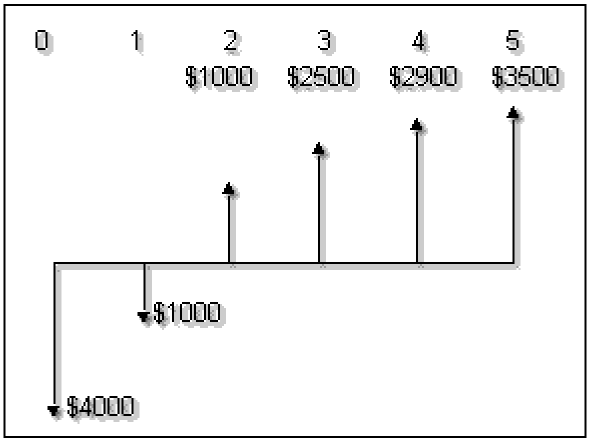
The present worth of this project at an interest rate of 10% is

$$P = -\$8000 + \$2000\, b^{2} + \$3500\, b^{3} + \$3900\, b^{4} + \$4500\, b^{5}$$

P = $1730

The project has a rate of return of **16%.**

There is a lender that is willing to lend us $4000 at approximately 8% interest. The repayments will be $1000 per year for 5 years. The net cash flow with respect to our own equity capital would yield the following leveraged project cash flow:



The present worth of the leveraged project at an interest rate of 10% is:

$$P = -\$4000 - \$1000\, b + \$1000\, b^{2} + \$2500\, b^{3} + \$2900\, b^{4} + \$3500\, b^{5}$$

P = $1950

The leveraged project has a rate of return of 20%. This demonstrates that leverage magnifies profitability. We have a project that has a rate of return of 16% that by borrowing increases the rate of return to 20%.

A leveraged project is defined, when a specific loan and repayment schedule is associated with a project, as the combined project whose cash-flow set is the sum of those of the loan and those of the project.

How does this relate to evaluation? The first assessment of any project should always be done without any leverage. As you can see, leverage magnifies the return on the firms' invested capital by "attributing" the excess return over the borrowed funds to the internal equity of the firm so the leveraged return is much higher.

This looks like a great deal for everyone, so what's the catch? Except in rare instances, investors will look at your total debt load and determine that they will require cashflow coverage of your interest payments. If one of the projects fails and you can't pay off the debt then you stand to lose your investment. Typically, there is a comfortable level of debt for a firm based on cashflow and assets that produces the firm-wide gain of leverage. With firm-wide consolidation of debt in a balance sheet, the use of unleverage capital budgeting is best.

In my opinion, the only specific use of leverage in financial calculations for a project is when the project has "no-recourse" finance or project specific finance. This is almost like a "stand-alone" company for that one project and can be analyzed on both an un-leveraged and leveraged basis to provide a perspective for the financing package for investors.