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Six Ways To Perform Economic Evaluation of Projects

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Six Ways to Perform Economic Evaluation of Projects

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COURSE CONTENT

Investment in any project entails significant capital and associated costs over the economic life of the project. It is usually possible to accomplish the same result with a variety of means and there are numerous examples of engineering systems that have a great physical design but little economic worth (i.e. it may simply be too expensive!!).

For instance, a proposal to invest in an automated machine for a welding operation on an automotive assembly line could trigger many questions:

1. Will the machine expand capacity (and thus permit us to exploit demand beyond our current limits)?
2. Will the machine reduce costs (at the current level of demand) and thus permit us to operate more efficiently than before we had the machine?
3. Will the machine create other benefits (e.g., higher quality, more operational flexibility)?
4. And finally, if the investment is worth undertaking!

The key economic question asked of project proposals should be, “How will things change (i.e., be better or worse) if we undertake the project?”

Engineers must decide if the benefits of a project exceed its costs, and must make this comparison in a unified framework. The framework within which to make this comparison is the field of engineering economics, which strives to answer exactly these questions, and perhaps more. The Accreditation Board for Engineering and Technology (ABET) states that engineering "is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind".

Economic analyses may be based on a number of cost classifications:

1. **First (or initial) Cost:** Cost to get activity started such as property improvement, transportation, installation, and initial expenditures.

2. **Operation and Maintenance Cost:** They are experienced continually over the useful life of the activity.

3. **Fixed Cost:** Fixed costs arise from making preparations for the future, and include costs associated with ongoing activities throughout the operational life-time of that concern. Fixed costs are relatively constant; they are decoupled from the system input/output, for example.

4. **Variable Cost:** Variable costs are related to the level of operational activity (e.g. the cost of fuel for construction equipment will be a function of the number of days of use).

5. **Incremental or Marginal Cost:** Incremental (or marginal) cost is the additional expense that will be incurred from increased output in one or more system units (i.e. production increase). It is determined from the variable cost.

6. **Sunk Cost:** It cannot be recovered or altered by future actions. Usually this cost is not a part of engineering economic analysis.

7. **Life-Cycle Cost:** This is cost for the entire life-cycle of a product, and includes feasibility, design, construction, operation and disposal costs.

All costs which may occur at various times, such as installation costs, maintenance costs, and any miscellaneous expenditure such as replacement of components, should also be treated as capital investment. Bringing all of these costs, which occur at different times, to a common point in time, allows the analyst to compare various design alternatives and select the alternative with the lowest total cost.

The principle underlying all types of investment is the net return expected from the proposed investment. This net return must be evaluated and compared with the overall investment in the project. An economic technique used to compare various design alternatives by projecting (discounting or compounding) associated costs over the economic life of the project, is known as **"Life Cycle Analysis (LCA)"**.

Mode of analysis

Payback period and **Return on investment** are two modes of analysis frequently used by plants that do not involve major capital investments. They are not fully consistent with the life cycle cost (LCC) approach in that they do not take into account all relevant values over the entire life period and discount them to a common time basis. Despite their disadvantages, these methods can provide a first level measure of profitability that is, relatively speaking, quick, simple, and inexpensive to calculate. Therefore, they may be useful as initial screening devices for eliminating more obvious poor investments.

The additional four modes of analysis that follow are fully consistent with the LCC approach:

- Total life cycle cost (present value method);
- Profitability index or benefit/cost ration method;
- Net present Value (NPV);
- Internal rate of return (IRR).

Each of the six modes of analysis just mentioned is presented with illustrations in the following sections. But before that, let's understand the concept of money:

Interest Rate

Interest is a rental amount charged by financial institutions for the use of money.

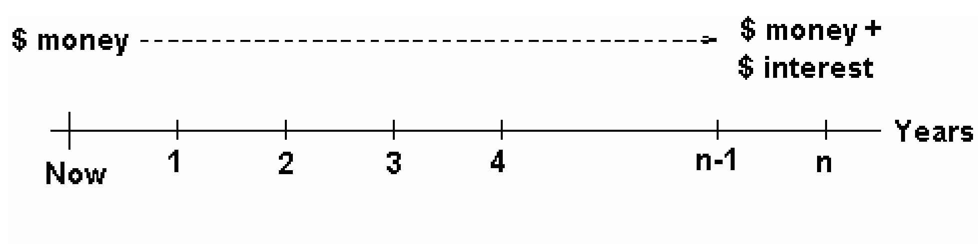
- Called also the rate of capital growth, it is the rate of gain received from an investment.
- It is expressed on an annual basis.
- For the lender, it consists, for convenience, of (1) risk of loss, (2) administrative expenses, and (3) profit or pure gain.
- For the borrower, it is the cost of using a capital for immediately meeting his or her needs.

Interest rate can be simple interest or compound interest. Simple interest is computed only on the original amount borrowed. It is the return on that principal for one time period. In contrast, compound interest is calculated each period on the original amount borrowed plus all unpaid interest accumulated to date.

Time Value of Money (TVM)

Money has time-value because the purchasing power of a dollar changes with time.

The time-value of money is the relationship between interest and time, i.e.



Time Value of Money

Time value of money analysis begins with the Present Value concept, the idea that money you have now is worth more, today, than an identical amount you would receive in the future.

Why?

There are at least 3 reasons:

1. **Opportunity.** The money you have now, you could (in principle) invest now, and gain return or interest, between now and the future time. Money you will not have until a future time cannot be used now.

2. **Risk.** Money you have now is not at risk. Money predicted to arrive in the future is less certain.

3. **Inflation.** A sum you have today will very likely buy more than an equal sum you will not have until years in future. Inflation over time reduces the buying power of money.

Earning Power of Money

The earning power of money represents funds borrowed for the prospect of gain.

Often these funds will be exchanges for goods, services, or production tools, which in turn can be employed to generate and economic gain.

Purchasing Power of Money

The prices of goods and services can go upward or downward, and therefore, the purchasing power of money can change with time.

- **Price Reductions:** Caused by increases in productivity and availability of goods.
- **Price Increases:** Caused by government policies, price support schemes, and deficit financing.

SIMPLE PAYBACK ANALYSIS

The Payback, also known as the payout or the payoff method, determines the number of years for the invested capital to be offset by resulting benefits. The required number of years is termed as the payback, recovery, or break-even period. The measure is popularly calculated on a before-tax basis, without discounting, i.e. neglecting the opportunity cost of the capital. Investment costs are usually defined as first costs that often neglect the salvage value. Benefits are usually defined as the resulting net change in income cash flow, or, in the case of a cost reducing investment like energy efficient devices, as the reduction in net outgoing cash flow.

The simple payback period is usually calculated as follows:

$$\text{Simple Payback Period (SPP)} = \frac{\text{First Cost}}{\text{(Yearly Benefits - Yearly Costs)}}$$

All other things being equal, the better investment is the one with the shorter payback period.

For example, if a project costs $100,000 and is expected to return $20,000 annually, the payback period will be $100,000 / $20,000, or five years.

There are two main problems with the payback period method:

1. *It ignores any benefits that occur after the payback period and, therefore, does not measure profitability. The method does not give consideration to cash flows beyond the payback period, and thus, does not measure the efficiency of an investment over its entire life.*

2. *It ignores the time value of money. The neglect of the opportunity cost of capital, or failing to discount costs occurring at different times to a common base for comparison, results in the use of inaccurate measures of benefits and cost to calculate the payback period, and hence, results in the determination of an incorrect payback period.*

Because of these reasons, other methods of capital budgeting like net present value, internal rate of return or discounted cash flow are generally preferred. Despite its limitation, there are several situations in which the payback method might be particularly appropriate:

1. *A rapid payback may be a prime criterion for judging an investment when financial resources are available to the investor for only a short period of time.*

2. *The speculative investor who has a very limited time horizon will usually desire rapid recovery of the initial investment.*

3. *When the expected life of the assets is highly uncertain, determination of the break-even life, i.e. payback period, is helpful in assessing the likelihood of achieving a successful investment.*

Example (SPP):

Find the SPP for providing a security system in a building complex that costs $100,000 to install and $5,000 per year on average to operate and maintain. The security system is expected to yield a saving of $60,000 a year as a result of reduced security staff.

$$\text{Simple Payback Period (SPP)} = \frac{100{,}000}{(60{,}000 - 5{,}000)}$$

$$= 1.82 \text{ years}$$

In other words, the cost or providing a security system will be recovered in 1.82 years, or around 22 months.

Example (SPP):

Find the simple payback considering the lighting retrofit of a 10,000-square-foot commercial office building. Re-lamping with T-8 lamps and electronic, high-efficiency ballasts may cost around $13,300 and produce annual savings of around $4,800 per year (80,000 kWh at $0.06/kWh).

$$\text{Simple Payback Period (SPP)} = \frac{\$\ 13{,}000}{\$\ 4{,}800}$$
$$= 2.8 \text{ years}$$

That is, the improvement would pay for itself in 2.8 years, a 36% simple return on the investment (1/2.8 = 0.36).

Discounted Payback Period (DPP)

Discounted payback is a variation of the simple payback period. The chief difference is that the discounted payback period method discounts, or takes into account the time value of money, cash flows. The discounted payback period is calculated as follows:

$$\text{Discounted Payback} = \text{Year before recovery} + \frac{\text{Unrecovered cost at start of the year}}{\text{Cashflow during the year}}$$

Let us illustrate finding Discounted Payback Period with an example investment proposal.

ABC Company is considering investing in a project. The initial investment in the project will be a cash flow of -$12,000. The projected cash flows of the project, including the initial investment, are: (-$12,000, $2,500, $4,000, $5,500, $6,000)

The ABC Company CEO has decided that the payback period for any project undertaken must be within 3 years. What is the projected discounted payback period of the project? Does the project meet the payback criteria set by the CEO? Assume a discount rate of 6%.

Solution

Step – 1:

Gather together all the information needed to find the discounted payback period.

The projected cash flows are (-$12,000, $2,500, $4,000, $5,500, $6,000)

Initial investment = -$12,000

Year 1 cash flow = $2,500

Year 2 cash flow = $4,000

Year 3 cash flow = $5,500

Year 4 cash flow = $6,000

Discount rate = 6%

Step – 2:

Discount the cash flows. Don't discount the initial investment.

Year 1 cash flow = $2,500/1.06

Year 1 cash flow = $2,358.49

Year 2 cash flow = $4,000/ $(1.06)^2$

Year 2 cash flow = $4,000/1.1236

Year 2 cash flow = $3,559.99

Year 3 cash flow = $5,500/ $(1.06)^3$

Year 3 cash flow = $5,500/1.191

Year 3 cash flow = $4,617.97

Year 4 cash flow = $6,000/ $(1.06)^4$

Year 4 cash flow = $6,000/1.2624

Year 4 cash flow = $4,752.85

Step - 3:

Determine the discounted payback period. At this point the discounted payback period method and the payback period method are identical.

The payback period is when the project will earn the value of the initial investment of $12,000.

$2,358.49 + $3,559.99 + $4,617.97 = $10,536.45

$10,536.45 < $12,000

The 3rd year is not the payback year.

$2,358.49 + $3,559.99 + $4,617.97 + $4,752.85 = $15,289.3

$15,289.3 > $12,000

The investment payback period is in the 4th year.

Step - 4:

Determine if the investment should be made. The CEO said that the payback period had to be within 3 years. The investment does not reach payback within 3 years and should be rejected.

Notice that if the cash flows had not been discounted the investment would have met the payback period criteria.

Example (DPP):

Find the discounted payback for an outlay of $250,000 for energy efficient equipment having a life of 8 years. This equipment will produce constant net annual savings of $75000. The discount rate is 10% per year.

Year	Discounted Savings	Cumulative Discounted Savings

1	75,000/1.1 =6,881.82	= 68,181.82
2	75,000/ 1.1^2 =61,983.47	= 130,165.29
3	75,000/ 1.1^3 =56,348.61	= 186,513.90
4	75,000/ 1.1^4 =51,226.01	= 237,738.91
5	75,000/ 1.1^5 =46,569.10	= (cumulative savings exceeds capital outlay)

The discounted savings is simply the anticipated future cash flows.

Capital outlay not yet recovered at the end of year 4 = \$250,000 – \$237,739.91 = \$12,260.09

Discounted Payback Period (DPP) = 4 + (12,260.09 / 46,569.10) = 4.26 years

RETURN ON INVESTMENT (ROI)

ROI is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio.

The return on investment formula:

$$\text{ROI} = \frac{(\text{Gain from Investment - Cost of Investment})}{\text{Cost of Investment}}$$

ROI analysis compares the magnitude and timing of investment gains directly with the magnitude and timing of investment costs. A high ROI means that investment gains compare favorably to investment costs. When potential investments compete for funds, and when other factors between the choices are truly equal, the investment—or action, or business case scenario—with the higher ROI is considered the better choice, or the better business decision. If an investment does not have a positive ROI, or if there are other opportunities with a higher ROI, then the investment should be not be undertaken.

Keep in mind that the calculation for return on investment and, therefore the definition, can be modified to suit the situation - it all depends on what you include as returns and costs. The definition of the term in the broadest sense just attempts to measure the profitability of an investment and, as such, there is no one "right" calculation. For example, a marketer may compare two different products by dividing the gross profit that each product has generated by its respective marketing expenses. A financial analyst, however, may compare the same two products using an entirely different ROI calculation, perhaps by dividing the net income of an investment by the total value of all resources that have been employed to make and sell the product.

The ROI method has the following principal disadvantages and therefore is not recommended as a sole criterion for investment decisions:

1. *Like the payback method, this method does not take into consideration the timing of cash flows, and thereby may incorrectly state the economic efficiency of projects.*
2. *The calculation is based on an accounting concept, original book value that is subject to the peculiarities of a firm's accounting practice which generally does not include all costs. The method therefore results in only a rough approximation of an investment's value.*
3. *ROI calculations can be easily manipulated to suit the user's purposes and the result can be expressed in many different ways. When using this metric, make sure you understand what inputs are being used.*

The advantages of the ROI method are that it is simple to compute and it is a familiar concept in the business community.

As an **example**, the calculation of the ROI for the investment in the security system referred previously mentioned is:

Original book value = $100,000

Expected life = 10 years

Annual depreciation using straight line method = 100000/10 = $10,000

Yearly operation, maintenance, and repair cost = $5,000

Expected annual savings due to reduced security staff = $60,000

Return on Investment (ROI) = 60000 – (10,000 + 5,000) x 100/100,000

= 0.45 x 100 = 45%

PRESENT VALUE

What future money is worth today is called its Present Value (PV), and what it will be worth in the future when it finally arrives is called "not surprisingly" its Future Value (FV). The right to receive a payment one year from now for $100 (the future value) might be worth to us today $95 (its present value). Present value is discounted below future value.

Since money has time value, we naturally expect the future value to be greater than the present value. The difference between the two depends on the number of compounding periods involved and the going interest rate. The present value of a promised future amount is worth less the longer you have to wait to receive it.

What determines this present value?

a) The amount of the payment or payments, of course

b) When in the future the payment(s) is to be made

c) The earning power of money over that future period of time-—the appropriate interest rate to use to discount the future dollar amounts.

Specifically: (other things constant)

a) The greater the amount of the payment(s), the greater the present value.

b) The more distant the future payment(s), the lower the present value.

c) The higher the interest, the lower the present value.

d) The higher the discount rate, the lower the present value.

Present Value—viewed another way:

Present value answers the question of how much money would have to be set aside today—and invested (at the appropriate interest rate)—in order to accumulate the target (payment) amount by the payment date. Instead of beginning with the principal which is invested, you could start from what you want to accumulate in the future, and then work backward to see the amount that you must invest to reach the required amount.

How to calculate PV?

Defining the present value (PV) as the cash in hand today that will be invested, and the future value (FV) as the amount of money you will possess when the investment has matured, you can then take the interest (i) per compounding period and the number (n) of periods between the present and future and compute

$$FV = PV (1+ i)^n$$

That is, multiply the present value by one plus the interest n times in order to get the future value.

Example:

If $100 is invested today at a 5% nominal annual rate, it will be worth $105 one year from now. In other words, the present worth of the $105 to be received next year is $100. If the investor leaves money in the account for another year, the account balance will grow to $110.25. An additional $0.25 has accrued over and above the first year's interest because the account has accumulated, or compounded, interest on interest.

To compute the future value (FV) of any investment amount (P) at an interest (i) over (n) number of years, the following formula may be used:

$$\text{Future Value (FV)} = P(1+i)^n \quad \text{------------------- Eq 1}$$

For the example above FV $= 100 \times (1 + 0.05)^2$ = $ 110.25

In many instances, investments are made more often than just at the beginning of the analysis period. Sometimes investors deposit periodic payments into an account. This greatly adds to the effect of compounding. When the same amount of money is paid, or received periodically, it is referred to as an **"Annuity".** When the money is invested or received at the end of the period, it is referred to as an ordinary annuity. To calculate the Future value of an ordinary annuity (A), the following formula may be used:

$$\text{Future Value (FV)} = \frac{A\,[\,(1+i)^n - 1\,]}{i} \quad \text{-------------------- Eq 2}$$

Example:

If $100 is deposited at the end of each year into a saving account paying 5% compounding annually, how much money will accumulate at the end of 5 years?

Using the annuity formula above, $FV = 100\,\{(1 + 0.05)^5 - 1\} / 0.05 = 552.56$

The present worth of any amount of money due in the future is calculated by a process known as **"discounting".**

The discounting process is important in LCC analysis because it facilitates the translation of future values to present values and makes investment decisions simpler. If the total cost of owning an asset is its initial cost and all subsequent costs, the subsequent costs must first be discounted to present value before they are combined with the initial cost to obtain the life cycle cost. It would be wrong to ignore the timing of the future costs and merely add them to initial cost.

All LCC analyses must be performed in terms of compatible dollars.

For equation 1 above, P = PV (Present value), Therefore

$$PV = FV\left[\frac{1}{(1+i)^n}\right] \quad \text{-------------------- Eq 3}$$

Substituting the value of FV in equation 2 into equation 3 yields,

$$PV = A \left[\frac{(1+i)^n - 1}{i(1+i)^n} \right] \text{ --------------------- Eq 4}$$

This factor is used to determine the present amount PV that can be paid by equal payments of A (uniform annual payment) at i % interest, for n years.

Example:

What single sum, deposited today at 8 percent interest compounded annually, would enable the withdrawal of $7,760.67 at the end of each of the next 3 years? In other words, find the "present value of a future annuity".

$$PV = 7760.67 \times \left[\frac{(1+0.08)^3 - 1}{0.08 \times (1+0.08)^3} \right]$$

= 7,760.67 x 2.57709 = $20,000

Thus the present value of a 3-year annuity of $7,760.67 at an interest rate of 8% compounded annually is $ 20,000.

Example:

How much money must be deposited today for a child's education, to grow to $20,000 in 10 years? A bank is offering a fixed deposit for 10 years @ 6.5% interest compounded annually.

$$PV = 20000 \times \left[\frac{1}{(1+0.065)^{10}} \right] = 20000 \times [0.5327] = \$10,654.52$$

Example:

A heating, ventilation and air conditioning (HVAC) system is expected to cost $125,000. A one time replacement is expected after 15 years at a cost of $500,000. Annual operating costs are expected to be $125,000 per year. The system is expected to have a salvage value of $250,000 after 30 years.

Using a 10 percent discounted rate, what is the total present value of the system over 30 years?

Solution:

Present value = PV

Cash outflows, or expenditures, are expressed in parentheses; cash inflows, in this case the salvage value, are not.

PV initial cost	=$ 125,000.00
PV of one time replacement	= $ 500,000 x 0.239393
	= 119,695.00
PV of operating costs	= $125,000 x (PV/A, 30 years, 10%)
	= 125,000 x 9.42691
	= (1,178,363.75)
PV of salvage	= 250,000 x (PV/F, 30 years, 10%)
	= 250,000 x 0.05731
	= 14,327.50

Total PV of system ($ 2533841.25)

PROFITABILITY INDEX (PI)

The profitability index, or PI, method compares the present value of future cash inflows with the initial investment on a relative basis. Therefore, the PI is the ratio of the present value of cash flows (PV) to the initial investment of the project.

$$PI = \frac{\text{PV of cash flows}}{\text{Initial investment}}$$

A PI of 0.75 means that the project returns 75 cents in present value for each current dollar invested.

In this method, a project is accepted if PI > 1 and rejected if PI < 1.

Note that the PI method is closely related to the NPV approach. In fact, if the net present value of a project is positive, the PI will be greater than 1. On the other hand, if the net present value is negative, the project will have a PI of less than 1. The same conclusion is reached, therefore, whether the net present value or the PI is used. In other words, if the present value of cash flows exceeds the initial investment, there is a positive net present value and a PI greater than 1, indicating that the project is acceptable.

PI is also known as a benefit/cash ratio (B/C) or saving/investment ratio (SIR)

Example:

What is the profitability index (PI) to install an energy efficient heat pump at a cost of $175,000? The estimated energy savings is $50,000 per year. The useful life of the heat pump is 12 years and the discounted rate is 14%.

Solution:

Present value (PV) cost	= $175,000
PV benefits	= 50,000 (PV/A, 15 years, 14%)
	= 50,000 x (5.66028)
	= $ 283,014
Profitability Index (PI)	= (PV benefits)/ (PV costs)

= 283,014/17,500

= 1.62

NET PRESENT VALUE (NPV)

Net present value is a discounted cash flow (DCF) analysis that compares the amount invested today to the present value of the future cash receipts from the investment. In other words, the amount invested is compared to the future cash amounts after they are discounted by a specified rate of return.

The net present value method discounts all of the cash flows of a project to a base year. These cash flows include, but are not restricted to, equipment costs, maintenance expenses, energy savings, and salvage values. The cash flows are discounted to reflect their time value. Once all of the cash flows are discounted to a base year, the cash flows are weighed on a common basis and can be added together to obtain a 'total net present value'. A positive net present value indicates an acceptable project. A negative NPV indicates that the project should not be considered.

Example

An engineer in the food industry is considering a heat recovery device- an economizer- in the flue of one of his company's many ovens. The economizer costs $500,000 and installation costs are expected to reach $250,000. Annual operating and maintenance costs are estimated at $25,000. The system has an expected operating life of 20 years, with a salvage value of $50,000. Energy savings resulting from the installation of the economizer are projected at $125,000 per year. Using a discounted rate of 10 percent, calculate the NPV of the proposed project.

Solution:

Present Value (PV)

PV initial equipment cost = $ 500,000

PV installation cost = $ 250,000

PV annual O&M expenses = 25,000 x (PV/A, 20 years, 10%)

	= 212,850
PV salvage value	= 50,000 x (PV/A, 20 years, 10%)
	= 7,425
PV energy savings	= 125,000 x (PV/A, 20years, 10%)
	= 1,064,200
Net present value	= 108,775

The positive net present value indicates that the project should proceed. Note that there are many ovens in the company that presumably could also benefit from use of an economizer to capture waste heat. The positive NPV for one project can become multiplicative when other similar projects are considered. The NPV method is similar to the total LCC method presented earlier, but includes the ability to compare projects with varying benefits.

What is difference between present value and net present value?

Present value is the result of discounting future amounts to the present. For example, a cash amount of $10,000 received at the end of 5 years will have a present value of $6,210 if the future amount is discounted at 10% compounded annually.

Net present value is the present value of the cash inflows minus the present value of the cash outflows. For example, let's assume that an investment of $5,000 today will result in one cash receipt of $10,000 at the end of 5 years. If the investor requires a 10% annual return compounded annually, the net present value of the investment is $1,210. This is the result of the present value of the cash inflow $6,210 (from above) minus the present value of the $5,000 cash outflow. (Since the $5,000 cash outflow occurred at the present time, its present value is $5,000.)

INTERNAL RATE OF RETURN (IRR)

An internal rate of return is also a discounted cash flow (DCF) analysis commonly used to evaluate the desirability of investments or projects. The IRR is defined as the interest rate that makes the **net present value** of all cash flow equal to zero. In financial analysis terms, the

IRR can be defined a discount rate that that makes the **present value** of estimated cash flows equal to the initial investment.

The higher a project's internal rate of return, the more desirable it is to undertake the project. Assuming all other factors are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first.

IRR method should not to be confused with the ROI method, which calculates the rate of return, that an investment is expected to yield. The internal rate of return method expresses each investment alternative in terms of rate of return, a compound interest rate.

The main problem with the IRR method is that it often gives unrealistic rates of return. Suppose the cut-off rate is 11% and the IRR is calculated as 40%. Does this mean that the management should immediately accept the project because its IRR is 40%? The answer is NO! An IRR of 40% assumes that a firm has the opportunity to reinvest future cash flows at 40%. If past experience and the economy indicate that 40% is an unrealistic rate for future reinvestments, an IRR of 40% is suspect. Simply speaking, an IRR of 40% is too good to be true! So unless the calculated IRR is a reasonable rate for reinvestment of future cash flows, it should not be used as a yardstick to accept or reject a project.

The rate of return is usually calculated by a process of trial and error whereby the net cash flow is compounded for various discount rates until its value is reduced to zero.

Example:

Calculate the internal rate of return for a heat exchanger that will cost $ 250,000, will last 10 years, and will result in fuel savings of $75,000 each year.

Solution:

Find the (i) that will equate the following:

$ 250,000 = 75,000 x (PV/A, 10 years, i =?)

To do this, calculate the net present value (NPV) for various i values, selected by visual inspection.

NPV 25% = ($ 75,000) x (3.571) - $ 250,000

= $ 267,825 - $ 250,000

= $ 17,825

NPV 30% = ($ 75,000) x (3.029) - $ 250,000

= $ 231,900 - $ 250,000

= $ 18,100

For i = 25%, the net present value is positive; for i = 30% the net present value is negative. Thus, for some discount rate between 25 and 30%, the present value benefits are equated to the present value costs. Without the benefit of a complete set of discount tables or an adequate calculator, interpolation between the two rates can be accomplished to find the rate more exactly:

i = 0.25 + (0.30-0.25) x17825/ (17,825 + 18,100)

= 0.275 or 27.5%

It would be necessary to compare this expected rate of return of 27.5% with a firm's minimum rate of return in order to make an investment decision.

How is IRR different from NPV?

Both the NPV method and the IRR method are Discounted Cash Flow **(**DCF) analysis used in making investment decisions.

- The NPV method involves computing the net present value of a potential investment using the company's cost of capital as a discount rate. Under this method, the company should accept any investment that has a net present value greater than zero and reject any others.

- The IRR method involves computing the interest rate for a potential investment that yields a net present value of all cash flows equal to zero. Under this method, the company should accept any investment that has an IRR greater than or equal to the company's cost of capital, and reject any others.

The major difference is that while NPV is an indicator of the value or magnitude of an investment and is expressed in monetary units (dollars for example), the IRR is the true interest yield expected from an investment expressed as a percentage.

IRR is normally easier to understand than the net present value or NPV for non-financial executives. It is often used to explain and justify investment decisions, although a good financial analyst should know that the IRR is after all an estimated value, especially when calculated in Excel, and should be used in conjunction with other financial metrics such as the NPV and comparable valuation multiples when presenting a business or investment case.

Do NPV and IRR method yield same results?

NO - A project selected according to the NPV may be rejected if the IRR method is used.

Suppose there are two alternative projects, X and Y. The initial investment in each project is $2,500. Project X will provide annual cash flows of $500 for the next 10 years. Project Y has annual cash flows of $100, $200, $300, $400, $500, $600, $700, $800, $900, and $1,000 in the same period. Using the trial and error method, you find that the IRR of Project X is 17% and the IRR of Project Y is around 13%. If you use the IRR, Project X should be preferred because its IRR is 4% more than the IRR of Project Y. But what happens to your decision if the NPV method is used? The answer is that the decision will change depending on the discount rate you use. For instance, at a 5% discount rate, Project Y has a higher NPV than X does. But at a discount rate of 8%, Project X is preferred because of a higher NPV.

*The purpose of this numerical example is to illustrate an important distinction: The use of the IRR always leads to the selection of the same project, whereas project selection using the NPV method depends on the **Discount Rate** chosen.*

Discount Rate

An important element of DCF analysis is the determination of the proper discount rate that should be applied to bring the cash flows back to their present value. Generally, the discount rate should be determined in accordance with the following factors:

- **Riskiness of the project:** The higher the risk, the higher the required rate of return.

- **Project Size and Life:** A 10-year project with an initial investment of $100,000 can hardly be compared with a small 3-year project costing $10,000. Actually, the large project could be thought of as ten small projects. Studies indicate that returns are also related inversely to the size of the entity. That is, a larger company will provide lower rates of return than a smaller company of otherwise similar nature. So if you insist on using the IRR and the NPV methods to compare a big, long-term project with a small, short-term project, don't be surprised if you get different selection results. The same is applicable to the projects with unequal lives.

- **Time horizon:** Generally, yield curves are upward sloping (longer term instruments command a higher interest rate); therefore, cash flows to be received over longer periods may require a slight premium in interest, or discount, rate.

- **Different Cash Flows:** Furthermore, even two projects of the same length may have different patterns of cash flow. The cash flow of one project may continuously increase over time, while the cash flows of the other project may increase, decrease, stop, or become negative. These two projects have completely different forms of cash flow, and if the discount rate is changed when using the NPV approach, the result will probably be different orders of ranking. For example, at 10% the NPV of Project A may be higher than that of Project B. As soon as you change the discount rate to 15%, Project B may be more attractive.

- **Real or nominal basis:** Market rates of interest or return are on a nominal basis. If the cash flow projections are done on a real basis (non-inflation adjusted), then the discount rate must be converted to real terms.

- **Income tax considerations:** If the cash flows under consideration are on an after-tax basis, then the discount rate should be calculated using an after-tax cost of debt in the cost of capital equation.

When are the NPV and IRR Reliable?

Generally speaking, you can use and rely on both the NPV and the IRR, if two conditions are met.

First, if projects are compared using the NPV, a discount rate that fairly reflects the risk of each project should be chosen. There is no problem if two projects are discounted at two different rates because one project is riskier than the other. Remember that the result of the NPV is as reliable as the discount rate that is chosen. If the discount rate is unrealistic, the decision to accept or reject the project is baseless and unreliable.

Second, if the IRR method is used, the project must NOT be accepted only because its IRR is very high. Management must ask whether such an impressive IRR is possible to maintain. In other words, management should look into past records, and existing and future business, to see whether an opportunity to reinvest cash flows at such a high IRR really exists. If the firm is convinced that such an IRR is realistic, the project is acceptable. Otherwise, the project must be re-evaluated by the NPV method, using a more realistic discount rate.

MAKING GO/NO-GO PROJECT DECISION

The following are 4 generic guidelines to make better investment decisions:

1. **Focus on cash flows, not profits.** One wants to get as close as possible to the economic reality of the project. Accounting profits contain many kinds of economic fiction. Flows of cash, on the other hand, are economic facts.

2. **Focus on incremental cash flows.** Focus on the changes in cash flows affected by the project. The analysis may require some careful thought: a project decision identified as a simple go/no-go question may hide a subtle substitution or choice among alternatives.

3. **Account for time. Time is money.** According to the theory of time preference, investors would rather have cash immediately (sooner than later). Use NPV as the technique to summarize the quantitative attractiveness of the project. Quite simply, NPV can be interpreted as the amount by which the market value of the firm's equity will change as a result of undertaking the project.

4. **Account for risk.** Not all projects present the same level or risk. One wants to be compensated with a higher return for taking more risk. The way to control for variations in risk from project to project is to use a discount rate to value a flow of cash that is consistent with the risk of that flow.

Course Summary

The course presented the basic understanding of cost analysis and covered 6 ways of computing profitability:

- *Payback Method*
- *Return on Investment (ROI)*
- *Total life cycle cost (present value method)*
- *Savings/investment ratio (benefit/cost ration method)*
- *Net present Value (NPV)*
- *Internal rate of return (IRR)*

The first two methods are not fully consistent with the LCC approach because they do not take into account all relevant values over the entire life period and discount them to a common time basis. They are however, simple, quick, and a convenient first level assessment or measure of profitability. They are good for projects that do not involve major capital investments. The remaining 4 methods use discounting techniques to assess the present and future value of money. They are recommended for capital intensive projects.