

A blue-tinted background image showing a 3D bar chart, a pie chart, and a calculator, symbolizing financial analysis and budgeting.

# FUNDAMENTALS OF CAPITAL BUDGETING

## ABOUT APTA CONSULTING

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APTA provides Financial modelling, Petroleum Economics evaluation & analysis, and Excel training for business modelling and data analysis to range of clients. Our clients range from blue chip to small enterprises and individuals. Our clients have access to high quality, cost effective modelling support delivered by team of experts around the world.

## APTA FINANCIAL MODELLING TEAM

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APTA's dedicated financial modeling team is led by Santosh Singh. Santosh has more than 12 years of industry experience. With a technical background in drilling engineering and further qualification in Finance and Economics, he has worked in a number of major technical and commercial functions and gained extensive experience in economics evaluation, business development and commercial agreements.

Santosh's commercial valuation and analysis experience covers Africa, Asia, and Eurasia to name a few. He has a proven ability in the fiscal regime modelling, investment analysis, and providing high quality support to management for the strategic investment decisions.



SANTOSH SINGH  
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# CAPITAL BUDGETING



High 674.97  
Low 432.18  
Return +12.5%Pop

Factors, policies

Key indicators

Age Index

Institutional  
Financial sector  
Corporate gov  
Legal and re  
Contract er  
pillar: Bi  
Human c  
Taxes  
Infras  
Cost

Financial

Equity securities	1,200
Debt securities	2,910
Bank deposits	4,220
Other securities	3,850
Total	12,200

99%

31.6%

# CAPITAL BUDGETING

Just like we all make our house hold budget on how much we are going to spend on food, how much on clothing, how much on entertainment etc., given our monthly earnings, so does companies and businesses do. We all need to ascertain how much money we got and how much we can spend with getting into trouble. But before we move to discuss about company budgeting process we need to understand what is a CAPITAL?

Let me explain the concept of Capital goods with an example. Suppose you go to restaurant, order food, pay money and when the food arrives you consume it. You paid for a certain 'benefit' once, and you received the 'benefit' once. Next day if want to enjoy that food again, you will have to pay again in the restaurant, only then will they serve you the dishes of your choice. Such kind of spending can be termed as operational expense. Once you have spent, the associated benefit arrives and you consume it. To consume or enjoy the benefit again and again you have to keep spending again and again. Such type of spend can be termed OPERATIONAL expense.

There are certain expenditures which bring us the benefit over a longer period of time. For example if you buy a car, you pay for it once only. But we benefit from its usage for years to come. We can say we 'consume' the benefit of car over multi periods. You don't have to pay for its usage over and over again. Such expenditure is termed as CAPITAL expenditure.

Capital Budgeting is the process of decision making that a company uses for deciding and allocating funds for various Capital investments or projects that generates cash flows for more than a year.

Why is this so important? It is very important because capital projects outlays are so large that any wrong decision can severely damage the balance sheet of a company. What the above line means is simply a wrong decision can wipe out the asset base of a company and reduce the shareholders' value.

## THE PROCESS

The exact process of capital budgeting is company specific but we can outline some generic principles and steps.

Step 1: Idea generation for investment projects

Step 1: Analyze individual proposed projects

Step 3: Planning the implementation of selected projects

Step 4: Monitoring and auditing the actual results of the project compared with the planned one.

The focus of this reading is on the Step 2, i.e. learning to analyze the associated cash flows and profitability of the proposed projects so that the most value accreting projects are recommended for selection. Fundamentally capital budgeting is a cost-benefit analysis. All capital projects can be grouped in one of the following categories.

1. Replacement projects: e.g. should we replace an old machine or buy a new one?
2. Expansion projects: e.g. expanding production facility
3. New product or services: e.g. drilling new wells to increase field production
4. Regulatory/safety/environmental projects: required by law, may not generate revenue.
5. Others: those project whose value cannot be ascertained on basis of traditional economic indicators such as NPV,IRR rules

## BASIC PRINCIPALS

- Cash is king. Decision is purely on the merit of cash flow, not net income which is an accounting concept and does not represent cash in the bank.
  - Cash flow timing is the key. (Recall time value of money. A \$ today is better than a \$ tomorrow)
  - Opportunity cost has to be factored in. One must be comparing the incremental cash flows generated due to the project, with that which would have been generated without undertaking the project.
    - All analysis has to be based on after-tax cash flow.
    - *Financing cost are ignored*

The last point is to be specially noted. When analyzing the NCF (net cash flow which by definition is total after tax cash flow) we should not be including the finance charges in the NCF. This is because the NCF is discounted using “required rate of return” to compute the NPV of the project. Financing charges are reflected in the discount rate already. So by including the financing cost in the NCF would double count the financing cost. Consequently the resultant NPV will be an under estimate.

The required rate of return that is used for discounting the NCF should be the one which the investors would normally require in order to be induced to invest in that project for its given riskiness. Depending on the project riskiness, the required rate of return would go up or down. If a project is more risky, the investor would demand a higher return and thus the analyst should be using a higher required rate of return as discount factor.

The discount rate is also referred as “opportunity cost of capital”, “cost of capital”, “hurdle rate” etc. Suppose the company can invest in many projects of a given risk level. The highest return that it can generate by investing in those possible opportunities happens to be 8%. Hence this 8% will act as a benchmark for the company or its opportunity cost. By not investing in that particular project it will be giving up on the 8% return. Therefore when it has to decide on where to invest its capital, it will always seek to invest in a project which will give it at least 8% or more than 8 % return on its investment. Thus 8% becomes the opportunity cost of capital or simply cost of capital for this company. It will use 8% as discount rate, provided the riskiness of the project it is trying to evaluate is similar to the benchmark project.

## PITFALLS TO AVOID

We discuss underneath some of the common mistakes to avoid while making an investment decision on capital projects.

**Sunk Cost:** An expenditure that was already made in the past is a sunk cost. Suppose an E&P company spent \$10 million to buy an exploration license of a drilling prospect last year. Today, it has to take decision whether to drill or not and make a further investment of \$100 million. Should it include the historical expenditure (sunk cost) in its analysis? Answer is a resounding no. The sunk cost is sunk, it’s gone. The focus has to be on the \$100 million (not \$10million + \$100 million) to be spent and the associated benefit. Only current and future cash flows should affect the decision, not the past cash flows.

**An opportunity cost:** An opportunity cost is the amount that you will lose if you don’t act upon that opportunity. Alternately, how much you would gain by making use of that opportunity. When we are analysing a project we should always include the opportunity cost of not doing the next best option. Suppose you have a parcel of land lying idle. You

want to construct a commercial complex on it and sell it. Doing so will generate you a cash flow of say \$100 million. Should you build the commercial complex on it? What else do you need to know?

Before you decide to go ahead with the construction, you should be asking yourself 'what is my opportunity cost? Your opportunity cost is the value of the alternate usages of the plot of land you own. You can lease the plot to a warehouse company that is willing to give you \$90 million. There is another option to sell the land to a residential property developer, who can pay you \$110 million. Now you have complete information on your alternatives, you know your opportunity cost is actually \$110 million. The commercial complex development does not generate value greater than your opportunity cost. So you should ignore that option.

**Incremental cash flow:** An incremental cash flow is the *extra cash flow* on top of what already exist. This extra cash flow is the result of the decision to undertake the project.  $\text{Incremental cash flow} = \text{total cash flow if you go ahead with the proposed project} - \text{total cash flow if you do not go ahead with the project}.$

**Externalities:** We have to look holistically on the proposed project investment and not just in isolation to itself. The proposed project may have consequences for other pre-existing projects cash flow or future undertakings of other projects (e.g. new product launch cannibalizing its own product market and thus reducing cash flow from that product line). Consideration should be given to the positive or negative cash flow impact of other projects affected by the proposed investment.

There can be externality effect not just within the company but even outside of the company (proposed project implementation may increase environmental pollution or other environmental issue whose cost is not borne by the company). All such cost and benefits should be incorporated in the analysis of the proposal.

**Cash flow pattern – Conventional vs. Unconventional cash flow:** A conventional project is such that the initial cash flows are negative followed by positive cash flows. This is because early periods are the time of cash investing in the project so the cash flow is will be negative. Once the project starts generating revenue, from then onward, the cash inflows start exceeding the cash outflows and net effect is cash flows remain positive.

Sometime later in the project some more investment may be required. In such situation the cash flow sign changes from positive to negative followed by positive again. This is not the norm and so such cash flows are called unconventional cash flows. Basically it means, cash flows changes sign from negative (in the early periods) to positive and then

again to negative followed by positive sign. The sign change may happen more than twice, depending on the investment and revenue profile.

Projects with unconventional cash flows present challenges in interpreting the NPV and IRR (internal rate of return, explained later) metrics. There may be two IRR in some cases!

## ECONOMIC INDICATORS USED AS DECISION CRITERIA

All capital investment appraisals require comparison of the *return* (profit made on the invested capital in a project) with the alternate investment. This necessitates formulating an index or indicator for comparing two or more projects.

We need to have several indicators or indices to evaluate a project proposal. This is because the financial and economic profitability cannot be encapsulated in one single indicator. Secondly, no one single indicator is suitable for all situations.

Two key profitability indicators are NPV and IRR. Other indicators generally used for capital budgeting are, payback period, discounted payback period, profitability index (PI), maximum exposure, and value to investment ratio (VIR). We will discuss each of them in detail here.

## NPV – NET PRESENT VALUE

An individual would like to receive a \$ today, rather than the same \$ next year. Because a \$ today is worth more than a \$ next year. NPV is just a time value measure of the investment cash flows. Two projects may have exactly same NCF, but differ in NPV. NPV is a better measure of value than NCF.

NPV Formula:

$$NPV = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \dots + \frac{CF_n}{(1+r)^n}$$

$CF_t$  = net cash flow in the time period t

t = time period

n = total number of periods

r = discount rate or cost of capital or opportunity cost of capital or hurdle rate



A quick example will clarify that. Assume your company is considering a drilling program which requires \$100 million outlay. In turn the field starts producing from year 1. Projected cash revenues are \$50 million, \$100 million, \$200 million, and \$100 million in next 4 years. There is no other expenditure and no taxes to consider (assume all figure in this question are after tax). The management asks you recommend on the go or no go decision for this project.

Here is how you should proceed:

First calculate the NCF (net cash flow = Cash inflow – cash out flow) of each year.

		Total	0	1	2	3	4
<b>Capital Outlay</b>	MM\$	-100	-100				
<b>Cash Revenue</b>	MM\$	450		50	100	200	100
<b>NCF</b>	MM\$	350	-100	50	100	200	100

Now let's calculate the value of the cash revenue of this project

$$PV = \$347 \text{ million} = \frac{50}{(1.1)^1} + \frac{100}{(1.1)^2} + \frac{200}{(1.1)^3} + \frac{100}{(1.1)^4}$$

The company should be willing to give up \$100 million in value today, *only if the program can create a value more than what is giving up* i.e. \$100 million in today's money. The present value of its cash generation is \$347 million.

Compared to the value of initial capital outlay the project can generate a value of

$$\$ 247 \text{ million} = \$347 \text{ million} - \$100 \text{ million}$$

Thus the company should go ahead with the program as this project adds value to the company by \$247 million in today's money.

We could also directly find the NPV of the net cash flow stream of this project and arrive at same conclusion.

NPV of this project as below (using 10% cost of capital, you got this information from the management!):

$$NPV = \$247 \text{ million} = -100 + \frac{50}{(1.1)^1} + \frac{100}{(1.1)^2} + \frac{200}{(1.1)^3} + \frac{100}{(1.1)^4}$$

*Notice that we did not discount the initial outlay.* The underlying assumption here is that \$100 million is spent at the outset, at the start of year 1. All other cash flow are supposed to occur at the end of the respective years.

Ok! So here the decision rules for NPV: Positive NPV project increase shareholder or investors value. Negative NPV reduces shareholders or investors value.

Accept the project if:  $NPV > 0$

Reject the project if:  $NPV < 0$

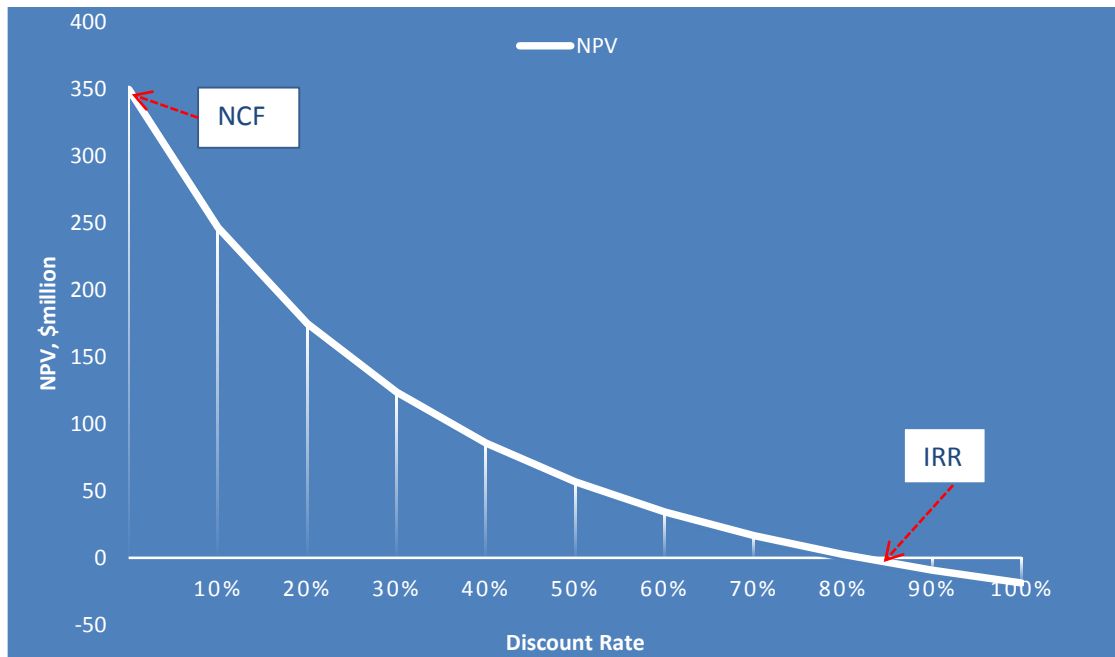
Happy with your analysis you recommend the project to your boss and the company management.

The next day, your boss asks you “If we go ahead with this project, when can we expect to recover our initial investment. And what return it will generate?”. Do not worry we will answer that for your boss now, but next time you will be answering it yourself. So read carefully!

## IRR – INTERNAL RATE OF RETURN

To answer your boss’s question we need to tell you about another key profitability indicator, IRR.

Before we explain it to you, let’s do some math again on the NPV. By now you would know that higher the discount rate, lower will be the NPV. This is because in the formula of NPV each period’s net cash flow is divided by a discount rate raised to the power ‘n’. That means NPV is inversely proportional to discount rate. So let’s plot curve of NPVs calculated at different discount rate (NPV on y-axis, discount rate on x-axis) for this particular drilling project.



As predicted, we see a downward sloping NPV curve. As the discount rate increase NPV goes down. This generally true in most case but in some case NPV profile can be upward sloping and then down ward sloping. That happens in the case of '*unconventional cash flow*' (we have discussed this earlier – a cash flow series with multiple sign change).

There are couples of noteworthy things in the graph of NPV vs discount rate.

At zero discount rate  $NPV = NCF$ . This should not be surprising. If we discount the NCF by zero discount rate, we will get the same numbers. In other words if you are given a NPV profile you can easily tell what is the NCF of the project. Just look where the NPV curve cuts the Y-axis (at y-axis, value of  $x=0$ , or 0 discount rate).

Secondly as discount rate keeps increasing NPV keeps getting smaller and smaller, until a point where it becomes zero. Alternatively at a certain discount rate, NPV curve cross the x-axis. This implies there exist discount rate at which NPV will cross the x-axis (meaning NPV will become 0 at that discount rate)

*Basically what this means is if your project's IRR is greater than your cost of capital (discount rate), your project is profitable; it is value accreting. If on the other hand the IRR turns out to be less than your cost of capital (discount rate); your project is value degrading.*

Conversely, it means that as long as you are discounting your cash flows with a rate less than the IRR, your project will be profitable. The moment you discount your project by

a rate greater than the IRR, your project will turn un-profitable (or negative NPV).

You have to keep in mind that you cannot arbitrarily choose your discount rate. It has to be related to the project's cost of capital which in turn will be correlated with the project's risk.

Now how do we calculate an IRR of project? You can tell that answer by looking at the NPV profile in the chart on the previous page. We can say that IRR of a project is the discount rate that will make the NPV of the project equal to zero. Therefore if we change the discount rate in the NPV formula such that  $NPV = 0$ , we would know that particular discount rate is the IRR.

IRR Formula:

$$NPV = 0 = CF_0 + \frac{CF_1}{(1 + IRR)^1} + \frac{CF_2}{(1 + IRR)^2} + \dots + \frac{CF_n}{(1 + IRR)^n}$$

IRR = internal rate of return

Remember your boss's question! He asked you about the rate of return from the drilling project. What he meant was what the IRR of the project is. Since we know the NPV of the project is positive at 10% discount rate, the IRR has to be higher than 10% (only then it can reduce the NPV to zero). We already did the calculation and plotted the NPV profile of this project, so by looking at the graph you can say the IRR of this project is 82%.

As seen from the IRR formula one cannot get a straight forward answer in one step. The equation for solving IRR is a polynomial equation and you would need a spreadsheet or a financial calculator to compute the IRR. Alternatively, it can be calculated using trial and error method. Keep inputting a discount rate until you reach close enough to zero. (In Excel you can use the GOAL SEEK function or use the IRR function.)

So here is the IRR rule for investment decision:

Accept the project if:  $IRR > \text{Cost of Capital}$

Reject the project if:  $IRR < \text{Cost of Capital}$

Since the IRR of this project is 82% this project is profitable at 10% discount rate. Even if the cost of capital or the opportunity cost of capital for this project increase to 15% or say 20%, the project will be profitable ( though less than if cost of capital were 10%). However of the cost of capital exceeds 82%, say it become 90% (we haven't heard of such a case in reality!), the project will no longer be profitable. At 90% cost of capital, projects NPV will turn negative as seen in the graph of NPV profile.

Next we will try to answer the second question, "When will the project recover its initial investment."

## PAYBACK OR PAYOUT

Payback is the time taken by the projects to generate an amount of money which is sufficient to recover all its initial investment. Basically it is the time required to get your investment capital back. And it is quite easy to compute. Simply accumulate the project net cash flows from start to end of project life. The point in time where the total cumulative NCF become zero for the first time is the payback period (the project will in most cases will have some initial investment upfront. This means the cumulative graph will always start from below the x-axis on the graph).

Let's calculate the cumulative NCF of the drilling project that we have been discussing so far:

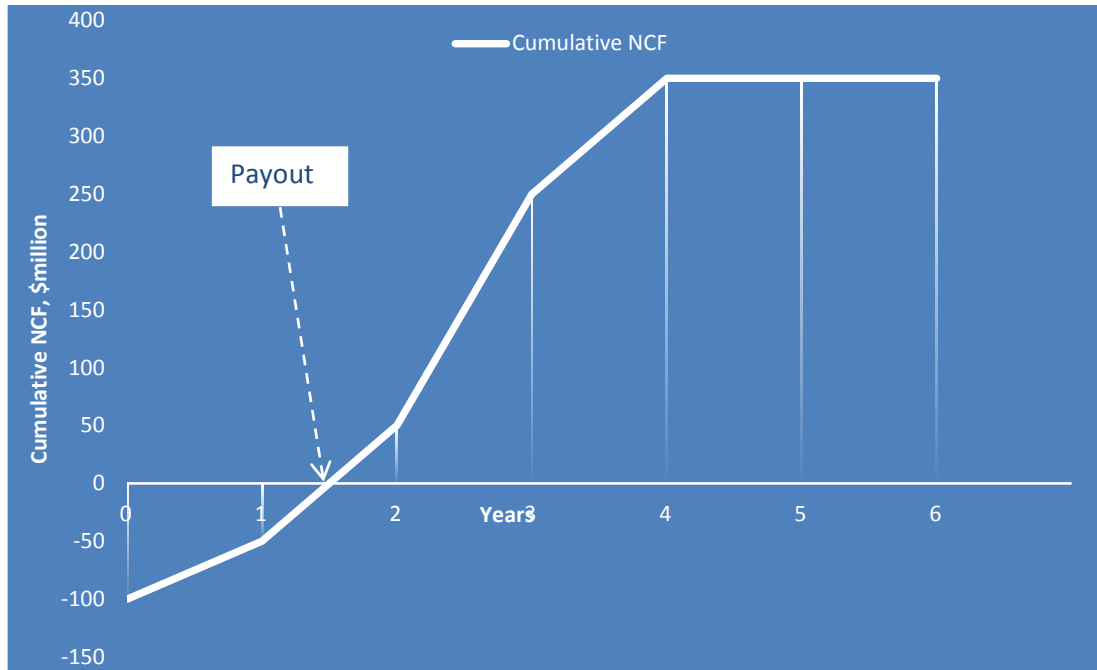
		0	1	2	3	4
NCF	MM\$	-100	50	100	200	100
Cumulative NCF	MM\$	-100	-50	50	250	350

Notice that at the start of the project we have \$100 million. So our Cumulative NCF at that point is - \$100 million. Our cumulative NCF by 1<sup>st</sup> year end is -\$50 million and by year 2 end its + \$50 million. Thus we recovered our initial investment in two years, first \$50 million was recovered in year 1 and the remaining \$50 million was recovered in year2. After recovering the total \$100 million in year 2, we are left with appositive cash balance of \$50 million. The payback period is thus 2 years.

If we assume for a minute that cash flow occurs throughout the year, we can be more precise in computing payback period. The total NCF in year 2 is \$100 million. The remaining amount to recover in year 2 is \$ 50 million. It would be recovered just in half of the year. So actually the payback period is 1.5 year.

It's often easier to visualize it on the NCF graph. Just plot the cumulative NCG graph

(Cumulative NCF vs. time on X- axis). The point in time where the cumulative NCF line cross the x-axis, is the payback period. If you note carefully the cumulative NCF line cuts the time line exactly in the middle between year 1 and year 2.



What does this indicator tell us about project profitability? Actually not much. Payback cannot tell anything about profitability of the project. It rather gives indication about the riskiness of the project. A project which takes longer to recover its investment (longer payback) is riskier than the one with shorter payback period.

Generally payback acts as a threshold for project approvals. Different companies have different policy about their acceptable payback periods. Some companies have more capacity and willingness for risk than others. Such company may have a higher threshold for payback (say 5 years) while other risk averse companies may have lower threshold (say 2 years).

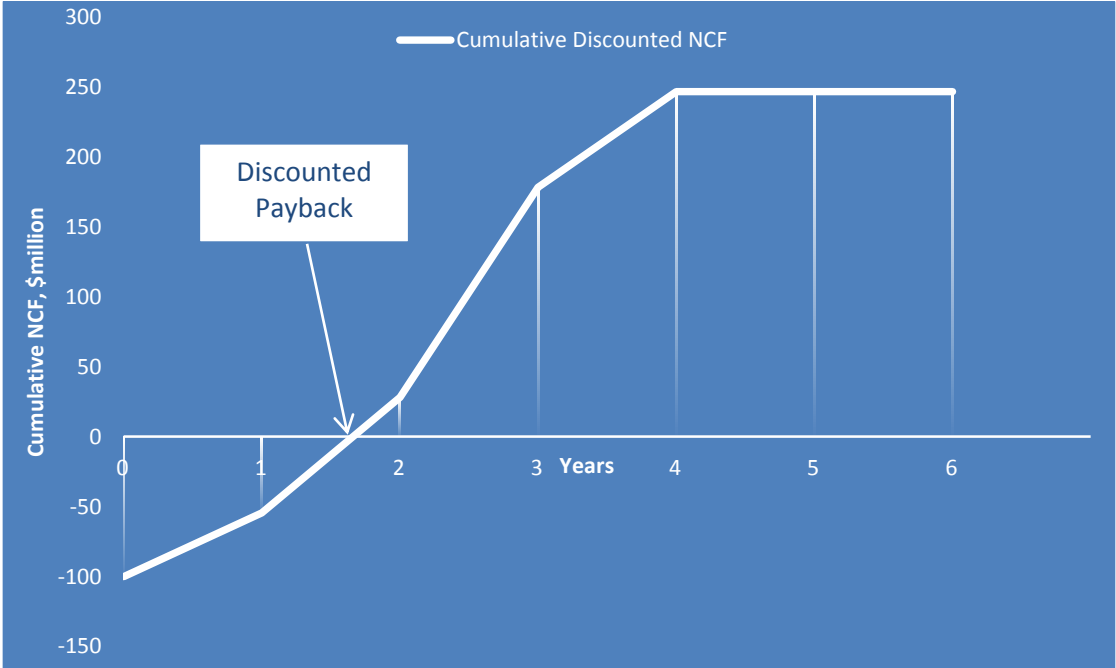
So the general rule is to accept the project if it meets the payback threshold. In case one has to select just on the basis of payback criteria then the project with a shorter payback will be accepted, the longer one will be rejected.

There is a problem with the payback indicator. *A project with shorter payback may be less risky than the one with longer payback. But it does not account for NCF and NPV beyond the payback period.* A project with shorter payback period in comparison to the one with longer payback, may have higher NCF and higher NPV.

Payback period also does not consider time value of money and hence the risk of the

project. Because it's based on cumulative NCF, the real payback in today's money terms may be actually longer than what you would arrive using cumulative NCF method.

The solution to incorporate time value impact on the payback period is to first calculate the discounted NCF of each period, then find the cumulative discounted NCF. The period where cumulative discounted CF exceeds zero for the first time is the discounted payback period. If you notice carefully on the graph, the discounted payback period is higher than the normal payback period. Even though the discounted payback period incorporates the time value by basing itself on discounted NCF, it still ignores NCF after the payback period.



Before you go to your boss to answer about the payback period, we need to tell you some drawbacks of payback indicator. Let's investigate this issue by solving an exercise.

Consider six proposed investment plan, as shown in the table below. We have solved the NPV and Payback period for each of them. Your job as an analyst is to tell us the implication of selecting or comparing these projects only on the merit of payback period. Study the cash flow pattern, their payback, and the associated NPV carefully.

Year	Project L	Project M	Project N	Project O	Project P	Project Q
0	-1,500	-1,500	-1,500	-1,500	-1,500	-1,500
1	1,500	200	300	700	500	1,500
2		400	600	750	500	100
3		600	400	800	500	100
4		300	200		500	100
5		600	600		500	7,000
Payback	<b>1.0</b>	<b>4.0</b>	<b>4.0</b>	<b>2.0</b>	<b>2.5</b>	<b>2.0</b>
NPV	<b>-136</b>	<b>41</b>	<b>78</b>	<b>357</b>	<b>395</b>	<b>4,436</b>

Project L:

The Payback is the shortest among all the projects. But notice, the project has negative NPV. So if someone prefers this project just because it's payback is the smallest, does not mean he is actually adding value to the company or the shareholders.

Comparing Project M with N:

Both projects has same payback period. Their NCF are also same after the payback period. So we can choose either of them. But that will be wrong advice. The reason is notice that N has better NPV than M (because the N got most of its cash flows occurring in the early part of the project compared to M)

Comparing Project O with P:

O has smaller payback than P. But P got higher NPV than O. Here we get conflicting decisions. The payback rule suggests project O is better. NPV rules suggest project P is better. The ultimate decision in such situation will depend on the corporate policy of the company. If their primary concern is payback then they will go for project O. But if their primary concern is value maximization, they will prefer project P.

Actually it's not just the company preference. Their preference will also be influenced by the capital constrains and the financing available to them.

Comparing Project O with Q:

This one reveals the real flaw in the payback selection criteria. Both project got the same payback period. But look how much more NCF is generated by project Q in after the year 3. The payback criteria does not account for those values at all.



So now equipped with the knowledge of payback period, you go back to tell your boss the answer. He is pleased with your analysis, but he wants to look at another investment proposal.

Your company has discovered a small oil field near the coast of Namibia. It is estimated that to develop that oil field about \$1,000 million will be required. The associated cash flow (after tax) is given in the table below. He wants to know what will be the maximum exposure of this project.

Year	0	1	2	3	4	5	6	7
Investments	-100	-150	-200	-200	-50			
Cash flows				200	300	300	250	200

What your boss has asked you is actually termed as Maximum Capital Exposure.

### Maximum Capital Exposure

In any given project all the investment is not required upfront in one single point in time. Capital is invested over a period of time. In big Oil and Gas projects, it takes years of capital spending before cash flow is generated. Most often the project starts generating cash even when the spending program is still going on. This is actually good news for investor. This allows them to kick start the project even when they don't have the total capital upfront. At some point the project become self-funding. The cash generated from the project is invested into the project. So there is no need to inject capital from outside.

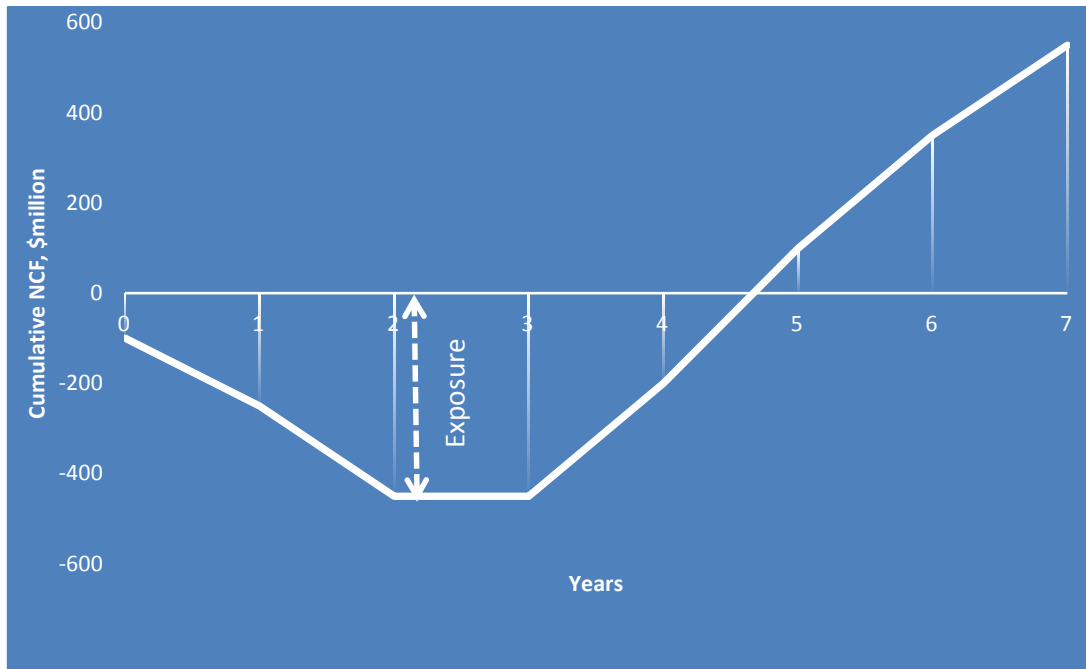
If we plot a cumulative NCF line, in the beginning phase it will be below the x-axis (meaning period of negative cash flow). Once project starts generating cash, the negative cumulative cash balance will start reducing and slowly move toward zero and then it will become positive.

The point where it cuts x-axis is the payback period. We already saw that. The point where there is the largest negative cumulative cash balance in the project is called Maximum Capital Exposure.

It shows the maximum amount of cash that needs to be supplied by the investor in the life of the project. The investor may not have the full capital outlay beforehand, but he must have an amount equal to maximum capital exposure. This criterion also indicates risk and project affordability. In a sense it shows the maximum downside.

To know the capital exposure is important for scheduling the investment project. One

should avoid a situation where the all projects reach their maximum exposure at the same period. This will put the management in a tight position, should there be problem in funding or debt management of the company.



To answer your boss query about capital exposure, we need to calculate the NCF of each period. Then compute Cumulative NCF. Find out the maximum negative cumulative NCF over the life of the project. That figure is negative \$450 million. Thus the maximum capital exposure is \$450 million. This can also be seen on the cumulative NCF graph above. You tell this to your boss and he looks satisfied.

The next indicator that we are going to discuss is called Profitability Index. This index is mostly used when we have multiple projects to choose from but can choose only a handful of them due to capital constraint or lack of sufficient available capital.

### Profitability Index or PI

Profitability Index is the ratio of PV of all future cash *inflows* and the initial investment.

PI Formula:

$$PI = \frac{PV \text{ of future cash inflows}}{\text{Initial investments}} = 1 + \frac{NPV}{\text{Initial Investment}}$$

It is not hard to see that whenever NPV is positive PI will be greater than 1. If NPV is negative PI will be less than 1.

The decision rule is for PI

**Accept the project if:  $PI > 1$**

**Reject the project if:  $PI < 1$**

What does PI actually tell us about the profitability? Looking at the formula of PI, we can say that it is like a 'unit' indicator. It tells us that for every unit of initial capital invested how much NPV is generated.

Now let's say we have two hypothetical projects, HC and LC. The NPV of both projects are the same, \$100 million. But project HC needs an initial investment of \$200 million whereas project LC requires only \$100 million.

If we have to pick only one of them we will be picking LC project. Why? Project HC has a PI of 1.5 ( $= 1 + 100/200$ ). Project LC has a PI of 2 ( $= 1 + 100/100$ ). Thus for \$1 invested in LC generate \$2 in cash flow whereas every \$1 invested in HC generates \$1.5 only. Clearly it makes sense to invest where the rate of return is more for each unit of investment.

### **Present Value Ratio (PVR)**

This is very similar to the Profitability Index and is the ratio of NPV to maximum Capital Exposure.

PVR Formula:

$$PVR = \frac{NPV}{\text{Maximum Capital Exposure}}$$

Since any positive NPV indicates acceptability of the project, the decision rule for PVR is:

**Accept the project if:  $PVR > 0$**

**Reject the project if:  $PVR < 0$**

So far we were just exploring the theoretical background of investment criteria. Having studied them, now we will see their applications in conflicting scenarios.

Be it PI or PVR, generally these indicators are used as 'cutting' indicator. Instead of ranking projects they allow the decision maker to exclude project not meeting certain threshold value of PI or PVR. For example if the corporate policy is not to invest in a project if the PI is less than 1.2 than all projects having PI under 1.2 will not be considered for inclusion.

The merit of PI or PVR over Payout or Maximum Exposure is that it gives due consideration to time value. But the demerit is that it ignores the size of the project. A smaller project (small investment and small NPV) may have better PI and PVR than a bigger project (large investment and large NPV). Being a ratio the absolute size of the project cannot be reflected by this indicator and may not do justice to investment decisions.

## NPV vs. IRR RANKING CONFLICTS

Generally you won't find conflicting decision based on NPV or IRR. Either of the two indicators will point in the same direction. Recall that the NPV criteria is for accepting a proposed investment based on NPV is: *Accept the project if NPV is positive*. If there are more than two projects, *the one with the highest NPV should be preferred over any other*. The IRR rule is also similar. *The project with the highest IRR is a better one*.

At times, generally when you have to decide on mutually exclusive projects (mutually exclusive projects are where you can choose one but not the other) you may encounter situation such that one project has the highest NPV and the other the highest IRR.

### Conflict due to cash flow pattern

Let's take an example (assume the discount rate for the project to be 10% and all figures are in million \$).

Year	0	1	2	3	4	5
Project Alpha	-300	200	150	100	50	0
Project Omega	-300	10	10	10	10	700

Which project is better in terms of NPV? In terms of IRR? Which one should we select if have to pick only one of the two?

First let's compute the NCF, NPV and IRR of these two options. Below is the table showing our calculations results:

	NCF	NPV	IRR
Project Alpha	200	115	31%
Project Omega	440	166	21%

This is what we were talking about. See the conflicting results! NPV of the project Alpha is lower than the NPV of the project Omega. But, IRR of the project Alpha is higher than that of project Omega. Situation like this do happen in real life and confounds many managers.

We are not bothered which project generates the highest NCF, as the management's decision criteria is NPV and IRR not the NCF (and rightly so, due to time value implications).

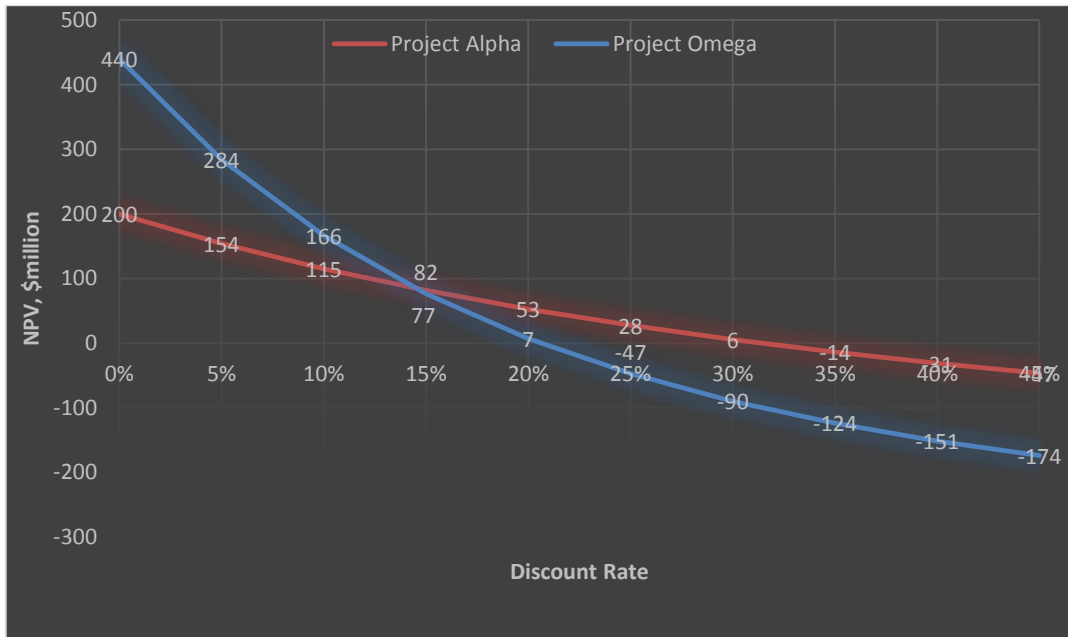
In such situations, it's always advisable to pick the project based on solely NPV criteria. In fact NPV is the gold standard of investment criteria. ***When in doubt go for NPV.***

The rationale behind the superiority of NPV is as follows. Every time we discount a cash flow series we implicitly assume that those cash flows can be re-invested at that rate. That's why we are discounting them at that assumed rate. Understand that for any acceptable project the NPV is positive. That also means that the discount rate used for discounting (the discount rate) is less than the IRR. If not then the NPV will be zero or negative. This implies the assumption of reinvestment is more conservative than what the IRR suggest.

In the above example the discount rate used is 10% and IRR of projects are 31% and 21%. Which one appears most likely rate for reinvesting the cash flow? We would say the lower rate 10%. That's why we should base decision on NPV if we are presented with conflicting results.

We will show you that there is actually another quirk in this example.

If we plot the NPV profile (NPV vs. discount rate) of the two projects we will notice there is a 'cross-over' point. There exists a discount rate below which project Omega has higher NPV than project Alpha. At discount rate above this 'cross-over' discount rate, NPV of project Alpha is higher than that of project Omega.



Thus when the cost of capital is 10% (discount rate = 10%), project Omega wins. Project OMEGA NPV is better than project Alpha as long as discount rate does not exceed 14.5%. After that point project Alpha's NPV is better than Alpha's.

We can make another conclusion from the chart; as long as they cost of capital for these two projects are below 14.5%, choose project Omega. If the cost of capital is above 14.5% then go for project Alpha.

There is another scenario where we often encounter with conflicting NPV vs. IRR results.

### Conflict due to project scales

The two projects in the above example had same initial investment (or the scale). Consider a third project Beta whose initial outlay is double of the project Alpha (the two projects different in scale). We present the cash flows, NCF, NPV and IRR of the project Alpha and Beta in tables below.

Year	0	1	2	3	4
Project Alpha	-300	200	150	100	50
Project Omega	-650	400	300	200	100

	NCF	NPV	IRR
Project Alpha	200	115	31%
Project Omega	400	192	24%

If these projects were not mutually exclusive, both the projects would be acceptable. Since these are mutually exclusive project, we have to accept only one of them. Should we undertake a bigger project with higher NPV but lower IRR or a smaller project with lower NPV but higher IRR?

Just as in previous case, we would base our decision on NPV and ignore IRR. We would select project Beta instead of Alpha. Same logic applies as before. The point of this example is to show you various situations where NPV and IRR may differ in ranking the projects. In this case the primary reason of conflicting results can be attributed to the initial investment size (the cash flow patter later are similar).

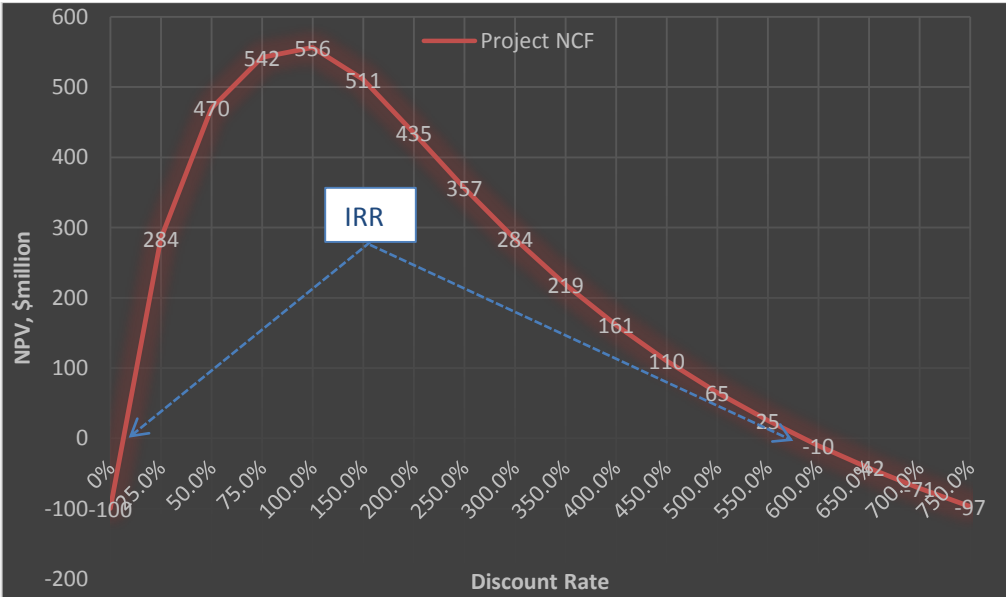
### MULTIPLE IRR & NO IRR SCENARIOS

There can situation while analyzing the cash flows you will end up getting two different IRR results. Remember an IRR equation is polynomial equation. A polynomial equation may have multiple solutions. So mathematically it's not unusual. But commercially it makes it difficult to interpret. Consider another case as shown below:

Consider the following project NCF:

Year	0	1	2	3	4	5
Project NCF	-600	5000	-6500	3000	-2000	1000

If we calculate the NPV at different discount rate for this cash flow profile, we get two IRR, 585% and 5.23%!



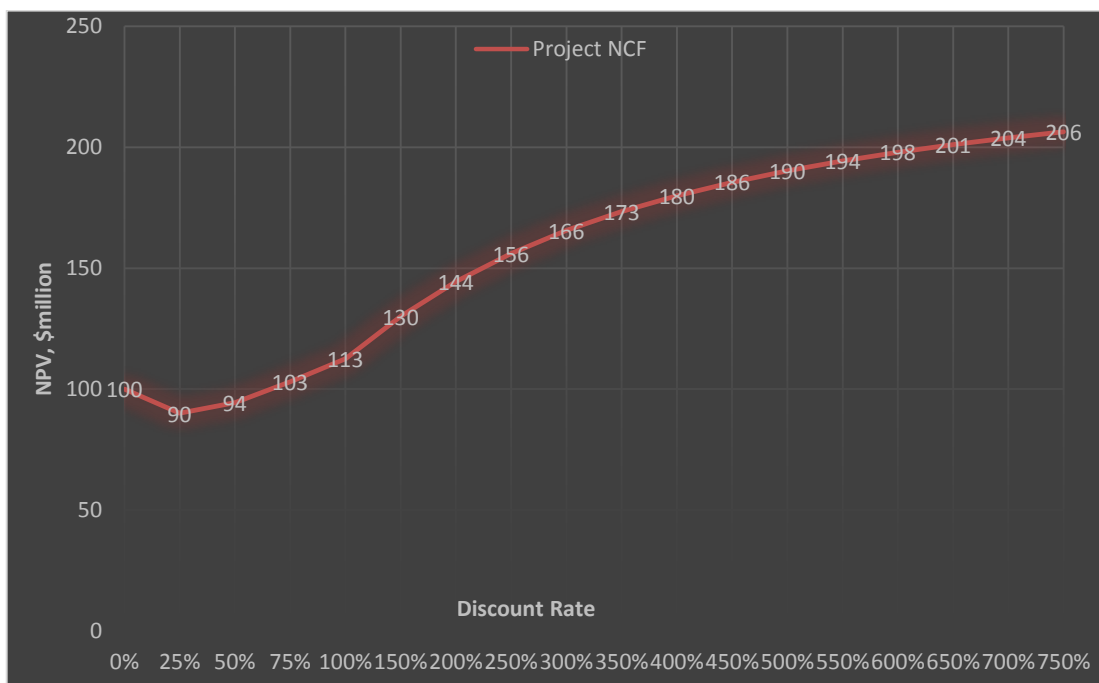
Consider another unusual cash flow pattern:

Year	0	1	2
Project NCF	250	-400	250

The equation to find the IRR for the above cash flows by first principle is:

$$NPV = 0 = 250 + \frac{-400}{1 + IRR} + \frac{250}{(1 + IRR)^2}$$

The above equation cannot be solved! Hence no IRR.



## ANALYSIS OF REPLACEMENT PROJECT

In general, when we have a replacement project where we replace an existing equipment or facilities the decision to invest in the project is based on the incremental cash flows. The relevant cash flows to compare will be the cash flows with the investment vs. the cash flows that would be generated without investing in the new project.

Let's show you an example to clarify the concept. Assume the following for the old machine and the new machine which will replace the new machine.



	OLD MACHINE	NEW MACHINE
<b>CURRENT BOOK VALUE</b>	500,000	
<b>CURRENT MARKET VALUE</b>	800,000	1,200,000
<b>REMAINING LIFE</b>	10	10
<b>ANNUAL REVENUE</b>	400,000	600,000
<b>CASH OPERATING EXPENSES</b>	100,000	150,000
<b>ANNUAL DEPRECIATION</b>	50,000	120,000
<b>SALVAGE VALUE</b>	200,000	400,000
<b>ADDITIONAL WORKING CAPITAL</b>		100,000
	Tax Rate	35%
	Required Return	10%

First we need to analyze how much is the incremental upfront investment. If we replace the old machine with the new machine, we invest \$1,200,000 in new machine, plus an additional investment of \$100,000 in working capital. Thus total of \$1,300,000.

Also we will sell the old machine at the current market value of \$800,000. Since this is more than the book value of the old machine, we will be required to pay capital gains tax. Our cash inflow due to this sale of machine will be  $\$800,000 - 35\% \times (\$800,000 - \$500,000)$

$$\begin{aligned} \text{Thus total outlay at the start} &= \$1,300,000 - (\$800,000 - 35\% \times (\$800,000 - \$500,000)) \\ &= \$1,300,000 - \$695,000 \\ &= \$605,000 \end{aligned}$$

Now for each of the 10 years the incremental cash flow

= {Incremental revenue - Incremental operating cost – Incremental depreciation} x (1 – Tax Rate) + Incremental depreciation

$$\begin{aligned} &= \{(\$600,000 - \$400,000) - (\$150,000 - \$100,000) - (\$120,000 - \$50,000)\} \times 65\% \\ &\quad + (\$120,000 - \$50,000) \end{aligned}$$

$$= \$122,000$$

Now we need to focus on the terminal year net post tax cash flow. In the end the new machine will be sold at \$400,000 which is \$200,000 more than salvage value of old machine. This incremental cash will attract capital gains tax. Thus total incremental cash flow at termination of project will be:

= Incremental Salvage value + Return of Working Capital – Tax on Capital Gain

$$= (\$400,000 - \$200,000) + \$100,000 - (\$400,000 - \$200,000) \times 35\% \\ = \$230,000$$

Now we know the cash flow of each year and we need to find the NPV of these incremental cash flows. If the NPV is >0 then we invest in the new machine, otherwise we continue with the same old machine.

$$NPV = - \$605,000 + \sum_{n=1}^{10} \frac{\$122,000}{(1+10\%)^n} + \frac{\$230,000}{(1+10\%)^{10}}$$

$$NPV = \$233,312$$

Since incrementally NPV is greater than 0 at 10%, we should accept the project proposal to invest in the new machine.

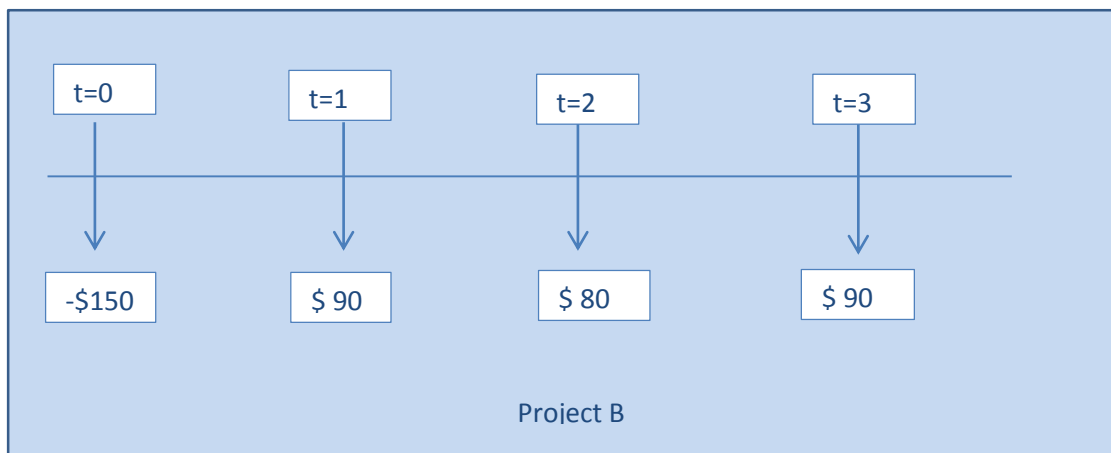
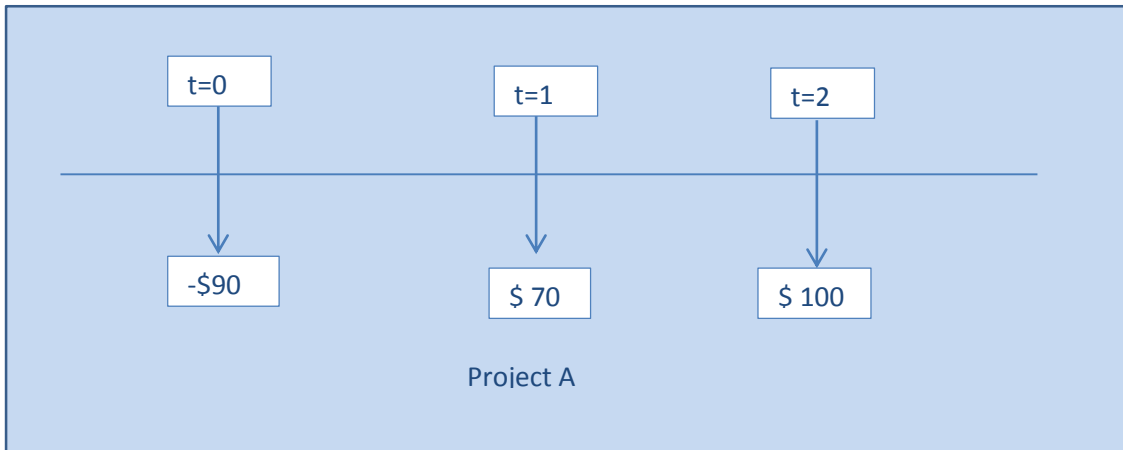
## ANALYSIS OF MUTUALLY EXCLUSIVE PROJECTS WITH UNEQUAL LIFE

Generally if we have two mutually exclusive projects, the one with the greater NPV wins. *In certain situation though this may not be the correct decision.* Such situations arise when we have to compare two projects which have different life span and they can be replaced or replicated. We would call projects which cannot be replaced/replicated as 'one shot' project. Some projects can be repeated over a number of times, we call them 'investment chain'.

There are two approaches to compare mutually exclusive projects with unequal lives.

- Equivalent Annual Annuity Approach
- Least Common Multiple of Lives Approach

Let's say there are two project opportunities A and B. Both will be replaced once they wear out. But we can choose only one of them. Their cash flows are shown in diagram below.



	Total	Period 0	Period 1	Period 2	Period 3
<i>NCF A</i>	80	-90	70	100	0
<i>NCF B</i>	110	-150	90	80	90
<i>NPV A</i>	56				
<i>NPV B</i>	66				

Project B looks better both on NCF and NPV basis. But what needs to be considered here is that Project A generates NPV of \$56 in just two years where as project B takes 3 years to generate a NPV of \$66. This implies we can put the money generated from project A in some other investment for an extra one year which may give us return which can be greater than the 3 years return of project B.

In other words we can think of this as two project which can be repeated again for next 2 years and next 3 years correspondingly. We need to make a common time line for these two projects to evaluate the NPV for this new timeline. We notice that project A's life is 2 years where as project B's life is 3 years. Thus we can pretend that both these

project can be run for 6 years (lowest common multiple of two lives, 2 years and 3 years). In 6 years project A can be repeated 3 times and project B can be repeated 2 times. Now that we have set up a common time frame we can re-asses the projects cash flow and their NPV. The re-worked cash flows are shown in table below.

Basically we invest the initial outlay of project A every two years and generate the cash flows. For project B we invest the initial outlay every three year and reap the benefit.

		PERIOD 0	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5	PERIOD 6
PROJECT A		-90	70	100				
PROJECT A				-90	70	100		
PROJECT A						-90	70	100
NCF A	<b>240</b>	-90	70	10	70	10	70	100
NPV A	<b>141</b>							

As you can see in the table we have repeated project A cash flow thrice and calculated NPV based on sum of the cash flow of all the three sub projects. The NPV works out to be \$141. There is an alternate approach for arriving at the NPV. Instead of repeating the cash flow thrice, we can assume that project A generates 3 NPV at end of period 0, end of period 2 and end of period 4 and calculate the PV of these three NPVs. They will work out to be same as before.

		PERIOD 0	PERIOD 2	PERIOD 4
NPV A	<b>141</b>	56	56	56

We repeat the process for project B. The table for project B is shown below:

		PERIOD 0	PERIOD 1	PERIOD 2	PERIOD 3	PERIOD 4	PERIOD 5	PERIOD 6
PROJECT B		-150	90	80	90			
PROJECT B					-150	90	80	90
NCF B	220	-150	90	80	-60	90	80	90
NPV B	<b>115</b>							

		PERIOD 0	PERIOD 3
NPV B	<b>115</b>	66	66

Now that we have brought both the project on the same time line, we can compare their NPV. Based on the new NPV project A looks better than project B.

There another method available to us to compare these two project with different project life span. The method is called EQUIVALENT ANNUITY APPROACH. For an investment project with outlay and cash flows its NPV simply represents the value of the project at time 0 (or some reference time period). Equivalent annuity payment of that particular investment project will be the equal periodic payment (or receipts) over the project life span such that the value of those annuity equals the NPV of the project. in the future periods.

So we can either say that a project generates so and so cash flows to give us a present value of X. Alternatively we can say the given project is equivalent to an annuity stream of Y whose present value equals X.

To use the equivalent annuity method first we calculate the projects NPVs as we will do normally for its give cash flow and time period. Then we use either PMT or GOAL seek function in Excel or use financial calculator to calculate the annuity amount such that its PV (calculated at interest rate equal to discount factor used) is the current NPV of the project.

The investment rule based on EAA (equivalent annuity approach) is to select project which has got highest EAA.

## CAPITAL RATIONING

A company encounters *Capital Rationing* situation when it has capital funding constraints and thus a limit on amount of money available for investments. Simply put, number of investment projects exceeds the total amount of capital available. Therefore, it can choose only few of the projects from a list of suitable projects. An example is shown below.

Assume we have 4 projects in which we can invest, as shown below. We have sufficient capital made available to us (We got \$1000 million to invest). So we can invest in all four if we want to.

	INVESTMENT OUTLAY	NPV	PI	IRR
	Million\$	Million\$		%
PROJECT A	550	220	1.37	15
PROJECT B	250	-70	1.35	16
PROJECT C	200	60	0.7	10
PROJECT D	300	-100	0.75	8

Should we be investing in all the four projects? Read carefully the NPV of project Band D. We should not be putting money in project B and project D because by doing so we are reducing the value by \$170million. So it's advisable that we just invest in project A and project C. Doing so will make us \$280 million in NPV and save \$200 capital. This saving can be invested elsewhere in profitable ventures.

Assume another scenario where the company has a budget of \$1000 million and it is presented with 4 different projects all with positive NPVs, as seen below.

	INVESTMENT OUTLAY	NPV	PI	IRR
	Million\$	Million\$		%
PROJECT L	750	400	1.5	15
PROJECT M	500	300	1.45	16
PROJECT N	180	100	1.4	12
PROJECT P	250	150	1.25	11

Given the unlimited capital budget, it will opt for all four projects. Now investing in project L and M can give maximum NPV, but they cannot invest in both L and M together. They will have to give up one of them due to capital constraints. They will thus invest in L and P (1st best and the 3<sup>rd</sup> best project) which in total will generate a NPV of \$550 million, which is less than the NPV of investing in L and M (\$700 million). Thus due to capital constraints the company will be forced to choose 1<sup>st</sup> and 3<sup>rd</sup> best projects as other combinations will violates the capital budget limit or will not maximize NPV.

## CAPITAL BUDGETING MISTAKES

- Not incorporating economic response into investment analysis
- Misusing capital budgeting templates
- Pet projects
- Basing decision on Net Income, EPS, ROE
- Using IRR as investment criterion
- Incorrect accounting for cash flows
- Overhead costs
- Not using suitable discount rate
- Spending just because it's made available
- Failure to see alternatives
- Incorrect usages of sunk cost and opportunity cost

