PROJECT MANAGEMENT

Project Evaluation (Capital Budgeting)

The main purpose of project evaluation or investment appraisal procedure is simply the comparison of uncertain future cash inflows with cash outflows which might also be uncertain. The basic techniques used by economists and financial analysts for this comparison purpose are most often internal rate of return and net present value techniques. This practice has been so generally accepted that the whole procedure of evaluating the profitability of an investment based on the concept of discounting is often referred to as the discounted cash flow techniques.

Method of Project Evaluation under Certainty

There are several methods for evaluating and ranking the capital investment proposals. In case of all these methods the main emphasis is on the return which will be derived on the capital invested in the project. In other words, the basic approach is to compare the investment in the project with the benefits derives there from.

Following are the main methods generally used:

1) Traditional Methods
    a) ***Pay-back Period*** Method
    b) ***Accounting Rate of Return*** Method.
2) Sophisticated/Discounted Cash Flow Methods
    a) ***The Net Present Value (NPV)*** Method
    b) ***Present Value Index Method/Benefit-Cost Ratio*** Method
    c) ***Internal Rate of Return (IRR)*** Method

Pay-back Period

The payback method of project appraisal calculates the length of time required for the stream of cash inflows from a project to equal the original cash outlay that is it can be defined as the number of years required to recover the cost of the investment.. The payback period is the length of time required for a stream of net cash inflows from a project to equal the original cash outlay.

It fails to consider the time value of money. Cash inflows, in the payback calculation, are simply added without suitable discounting. It ignores cash flows beyond the payback period. It ignores cash flows beyond the payback period. This leads to discrimination against projects which generate substantial cash inflows in later years.

Pay-back period = Initial investment /Annual cash inflows

Accept/Reject criteria: If the actual pay-back period is less than the predetermined pay-back period, the project would be accepted. If not, it would be rejected.

Merits of Pay-back method

1. It is easy to calculate and simple to understand.
2. Pay-back method provides further improvement over the accounting rate return.
3. Pay-back method reduces the possibility of loss on account of obsolescence.

Demerits

1. It ignores the time value of money.
2. It ignores all cash inflows after the pay-back period.

Exercise 1: Project cost is Rs. 30,000 and the cash inflows are Rs. 10,000, the life of the project is 5 years. Calculate the pay-back period.

Solution Pay-Back Period = Rs. 30,000/Rs. 10,000 = 3 Years

Exercise 2: A project costs Rs. 2000000 and yields annually a profit of Rs. 300000 after depreciation @ 12½% but before tax at 50%. Calculate the pay-back period.

Profit after depreciation	300000
Tax 50%	150000
	150000
Add depreciation 2000000 @ 12.5 %	250000
Cash inflow	400000

Pay-back period = Investment/Cash flow

= 2000000/400000

= 5 years.

Uneven Cash Inflows

Normally the projects are not having uniform cash inflows. In those cases the pay-back period is calculated, cumulative cash inflows will be calculated and then interpreted.

Exercise 3: Certain projects require an initial cash outflow of Rs. 25,000. The cash inflows for 6 years are Rs. 5,000, Rs. 8,000, Rs. 10,000, Rs. 12,000, Rs. 7,000 and Rs. 3,000.

Solution

Year	Cash Inflows (Rs.)	Cumulative Cash Inflows (Rs.)
1	5,000	5,000
2	8,000	13,000
3	10,000	23,000
4	12,000	35,000
5	7,000	42,000
6	3,000	45,000

The above calculation shows that in 3 years Rs. 23,000 has been recovered Rs. 2,000, is balance out of cash outflow. In the 4^{th} year the cash inflow is Rs. 12,000. It means the pay-back period is three to four years, calculated as follows
Pay-back period = 3 years + (2000/12000) × 12 months = 3 years 2 months.

Post Pay-back Profitability Method: One of the major limitations of pay-back period method is that it does not consider the cash inflows earned after pay-back period and if the real profitability of the project cannot be assessed. To improve over this method, it can be made by considering the receivable after the pay-back period. These returns are called post pay-back profits.

Exercise 4

From the following particulars, compute:
1. Payback period.
2. Post pay-back profitability and post pay-back profitability index.

(a) Cash outflow Rs. 100000
Annual cash inflow Rs. 25000
(After tax before depreciation)
Estimate Life 6 years

(b) Cash outflow Rs. 100000
Annual cash inflow
(After tax depreciation)
First five years Rs. 20000
Next five years Rs. 8000
Estimated life 10 Years
Salvage value Rs. 16000

Solution

(a) (i) Pay-back period = Initial investment/Annual cash inflows
= 100000/25000 = 4 Years

(ii) Post pay-back profitability = Cash inflow (Estimated life – Pay-back period)
= 25000 (6 – 4) = Rs. 50,000

(iii) Post pay-back profitability index = (50,000/100000) × 100 = 50%

(b) Cash inflows are equal therefore payback period is calculated as follows:

(i)

Year	Cash Inflows (Rs.)	Cumulative Cash Inflows (Rs.)
1	20,000	20,000
2	20,000	40,000
3	20,000	60,000
4	20,000	80,000
5	20,000	1,00,000
6	8,000	1,08,000
7	8,000	1,16,000
8	8,000	1,24,000
9	8,000	1,32,000
10	8,000	1,40,000

(ii) Post pay-back profitability.
= Cash inflow (estimated life – pay-back period)
= 8,000 (10–5) = 8000 × 5 = 40,000

(iii) Post pay-back profitability index = (40,000/100000) × 100=40%

Accounting Rate of Return or Average Rate of Return

Average rate of return means the average rate of return or profit taken for considering the project evaluation. This method is one of the traditional methods for evaluating the project proposals:

Merits

1. It is easy to calculate and simple to understand.
2. It is based on the accounting information rather than cash inflow.
3. It is not based on the time value of money.

Demerits

1. It ignores the time value of money.
2. It ignores the reinvestment potential of a project.
3. Different methods are used for accounting profit. So, it leads to some difficulties in the calculation of the project.

Exercise 5

A company has two alternative proposals. The details are as follows:

	Proposal I	Proposal II
	Automatic Machine	Ordinary Machine
Cost of the machine	Rs. 2,20,000	Rs. 60,000
Estimated life	5½ years	8 years
Estimated sales p.a.	Rs. 1,50,000	Rs. 1,50,000
Costs : Material	50,000	50,000
Labour	12,000	60,000
Variable Overheads	24,000	20,000

Compute the profitability of the proposals under the return on investment method.

Solution

	Automatic Machine	Ordinary Machine
Cost of the machine	Rs. 2,20,000	Rs. 60,000
Life of the machine	5½ years	8 years
	Rs.	Rs.
Estimated Sales	(A) 1,50,000	1,50,000
Less : Cost : Material	50,000	50,000
Labour	12,000	60,000
Variable overheads	24,000	20,000
Depreciation (1)	40,000	7,000
Total Cost	(B) 1,26,000	1,37,000
Profit (A) – (B)	24,000	12,500

Working:

(1) Depreciation = Cost ÷ Life

Automatic machine = 2,20,000 ÷ 5½ = 40,000

Ordinary machine = 60,000 ÷ 8 = 7,500

$$\text{Return on investment} = \frac{\text{Average profit}}{\text{Original investment}} \times 100$$

$$= \frac{24,000}{2,20,000} \times 100 \qquad \frac{12,500}{60,000} \times 100$$

10.9% 20.8%

Automatic machine is more profitable than the ordinary machine.

Net Present Value

Net present value method is one of the modern methods for evaluating the project proposals. In this method cash inflows are considered with the time value of the money. Net present value describes as the summation of the present value of cash inflow and present value of cash outflow. Net present value is the difference between the total present value of future cash inflows and the total present value of future cash outflows.

Merits

1. It recognizes the time value of money.
2. It considers the total benefits arising out of the proposal.
3. It is the best method for the selection of mutually exclusive projects.
4. It helps to achieve the maximization of shareholders' wealth.

Demerits

1. It is difficult to understand and calculate.
2. It needs the discount factors for calculation of present values.
3. It is not suitable for the projects having different effective lives.

Accept/Reject criteria

If the present value of cash inflows is more than the present value of cash outflows, it would be accepted. If not, it would be rejected.

Exercise 6

From the following information, calculate the net present value of the two project and suggest which of the two projects should be accepted a discount rate of the two.

	Project X	**Project Y**
Initial Investment	Rs. 20,000	Rs. 30,000
Estimated Life	5 years	5 years
Scrap Value	Rs. 1,000	Rs. 2,000

The profits before depreciation and after taxation (cash flows) are as follows:

	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
	Rs.	Rs.	Rs.	Rs.	Rs.
Project **X**	5,000	10,000	10,000	3,000	2,000
Project **Y**	20,000	10,000	5,000	3,000	2,000

The following are the present value factors @ 10% p.a.

Year	1	2	3	4	5	6
Factor	0.909	0.826	0.751	0.683	0.621	0.564

Solution

Year	Cash Inflows Project X Rs.	Project Y Rs.	Present Value of Rs. 1 @ 10%	Present Value of Net Cash Inflow Project X Rs.	Project Y Rs.
1	5,000	20,000	0.909	4,545	18,180
2	10,000	10,000	0.826	8,260	8,260
3	10,000	5,000	0.751	7,510	3,755
4	3,000	3,000	0.683	2,049	2,049
5	2,000	2,000	0.621	1,242	1,242
Scrap Value	1,000	2,000	0.621	621	1,245
Total present valueInitial investments				24,227 20,000	34,728 30,000
Net present value				4,227	4,728

Project Y should be selected as net present value of project Y is higher

Exercise 7

The following are the cash inflows and outflows of a certain project.

Year	Outflows	Inflows
0	175000	-------
1	550000	35000
2		45000
3		65000
4		85000
5		50000

The salvage value at the end of 5 years is Rs. 50,000. Taking the cutoff rate as 10%, calculate net present value.

Year	1	2	3	4	5
P.V.	0.909	0.826	0.751	0.683	0.621

Solution

Year	Cash Inflows Rs.	Present Value Factor @ 10%	Present Value of Cash Inflows
1	35,000	0.909	31815
2	45,000	0.826	37170
3	65000	0.751	48815
4	85000	0.683	58055
5	50000	0.621	31050

5(Salvage)	50000	0.621	31050

Total present value of cash inflows	237955
Less*: *Total present value of outflows	
Cash outflow at the beginning	175000
Cash outflow at the end of first year (50000 × 0.909)	45,450
Total value of outflows	220450
Net Present Value	**17505**

If the cash inflows are not given in that cases the calculation of cash inflows are Net profit after tax + Depreciation. In this type of situation first find out the Net profit after depreciation and deducting the tax and then add the deprecation. It gives the cash inflow.

Exercise 8 From the following information you can learn after tax and depreciation concept.

Initial Outlay	**Rs. 1,00,000**
Estimated life	5 Years
Scrap Value	Rs. 10,000
Profit after tax :	
End of year 1	Rs. 6,000
2	Rs. 14,000
3	Rs. 24,000
4	16,000
5	Nil

Solution

Depreciation has been calculated under straight line method. The cost of capital may be taken at 10%. P.a. is given below.

Year	1	2	3	4	5
PV factor @ 10%	0.909	0.826	0.751	0.683	0.621

$$\text{Depreciation} = \frac{\text{Initial cash outflow} - \text{scrap value}}{\text{Estimated Life of the project}}$$

$$= \frac{1,00,000 - 10,000}{5}$$

$$= \frac{90,000}{5} = \text{Rs.}18,000$$

Year	Profit after Tax	Depreciation	Cash Inflow
1	6,000	18,000	24,000
2	14,000	18,000	32,000
3	24,000	18,000	42,000
4	16,000	18,000	34,000
5	Nil	18,000	18,000

Net Present Value

Year	Cash Inflow	Discount factor @ 10%	Present value (Rs.)
1	24,000	0.909	21,816
2	32,000	0.826	26,432
3	42,000	0.751	31,542
4	34,000	0.683	23,222
5	18,000	0.621	11,178

Total present value of cash inflows	1,14,190
Less : Initial cash investment	1,00,000
Net present value	1,41,90

Exercise 9 Calculate NPV for a Project X initially costing Rs. 250000. It has 10% cost of capital. It generates following cash flows:

Year	Cash flows	PV @ 10%	PV
1	90000	0.909	81810
2	80000	0.826	66080
3	70000	0.751	52570
4	60000	0.683	40980
5	50000	0.621	31050
		ΣPV	272490
	Less:	NCO	250000
		NPV(Rs.)	22490

As the project has positive NPV, i.e. present value of cash inflows is greater than the cash outlays, it should be accepted.

Internal Rate of Return

Internal rate of return is time adjusted technique and covers the disadvantages of the traditional techniques. In other words it is a rate at which discount cash flows to zero. It is expected by the following ratio:

= (Cash inflow/Investment initial)

Steps to be followed:

Step1. Find out factor where Factor is calculated as follows: F = Cash outlay (or) initial investment/Cash inflow
Step 2. Find out positive net present value
Step 3. Find out negative net present value
Step 4. Find out formula net present value

Formula

$$\text{IRR} = \text{Basc factor} + \frac{\text{Positive net present value}}{\text{Difference in positive and Negative net present value}} \times \text{DP}$$

Base factor = Positive discount rate & DP = Difference in percentage

Merits

1. It considers the time value of money.
2. It takes into account the total cash inflow and outflow.
3. It does not use the concept of the required rate of return.
4. It gives the approximate/nearest rate of return.

Demerits

1. It involves complicated computational method.
2. It produces multiple rates which may be confusing for taking decisions.
3. It is assume that all intermediate cash flows are reinvested at the internal rate of return.

Accept /Reject criteria

If the present value of the sum total of the compounded reinvested cash flows is greater than the present value of the outflows, the proposed project is accepted. If not it would be rejected.

When any project generates uneven cash flow the IRR can be found out by trial and error. If the calculated present value of the expected cash inflow is lower than the present value of cash outflows a lower rate should be tried and vice versa. This process can be repeated unless the NPV becomes zero.

Example 10: A project costs Rs. 32,000 and is expected to generate cash inflows of Rs. 16,000, Rs.14000 and Rs. 12000 at the end of each year for next 3 years. Calculate IRR.

Let us take first trial by taking 10% discount rate randomly. A positive NPV at 10% indicates that the project's true rate of return is higher than 10%. So another trial is taken randomly at 18%. At 18% NPV is negative. So the project's IRR is between 10% and 18%.

Year	Cash flows	PV @ 10%	PV	PV @ 18%	PV
1	16000	0.909	14544	0.847	13552
2	14000	0.826	11564	0.718	10052
3	12000	0.751	9012	0.609	7308
		ΣPV	35120	ΣPV	30912
		NCO	32000	NCO	32000
		NPV	3120	NPV	(1088)

$$IRR = r + \left(\frac{PV_{co} - PV_{CFAT}}{\Delta PV} \times \Delta r \right)$$

Where,

PV_{co} = Present value of cash outlay

PV_{CFAT} = Present value of cash inflows at lower rate

r = Lower rate

Δr = Difference between higher and lower rate

ΔPV = Difference between PV of CFAT at lower rate and higher rate

Difference in Lower Rate & Higher Rate — Difference in CFAT at Lower rate & Higher rate

8%

- 10% PV at Lower rate — PV Required Rs. 32000 — Rs. 3120
- 10% PV at Lower rate — Rs. 35120
- 18% PV at Higher rate — Rs. 30912 — Rs. 4208

∴ IRR = 15.93% = 16%

When any project generates equal cash flows every year, we can calculate IRR as follows.

Exercise 11: An investment requires an initial investment of Rs. 6,000. The annual cash flow is estimated at Rs. 2000 for 5 years. Calculate the IRR.

NPV = (Rs.6000) + Rs.2000 (PVAIF5, r) = 0

Rs. 6000 = 2,000 ($PVAIF_{5, r}$)

$PVAIF_{5, r}$ = Rs 6000/Rs 2000 = 3

The rate which gives a PVAIF of 3 for 5 years is the project's IRR approximately. While referring PVAIF table across the 5 years row, we find it approximately fewer than 20% (2.991) column. Thus 20% (approximately) is the project's IRR which equates the present value of the initial cash outlay (Rs. 6000) with the constant annual cash flows (Rs. 2000 p.a.) for 5 years.

Decision Rule:

When IRR is used to make accept-reject decisions, the decision criteria are as follows

- If the IRR is greater than the cost of capital, accept the project. (r > k)
- If the IRR is less than the cost of capital, reject the project. (r < k)

Cash Flow (Rs)	Discount Rate	NPV (Rs)
(6000)	0%	4000
2000	5%	2659
2000	10%	1582
2000	19%	115
2000	19.86%	0
2000	35%	(1560)

Comparison of NPV and IRR

Both NPV and IRR will give the same results (i.e. acceptance or rejections) regarding an investment proposal in following two situations.

1. When the project under consideration involve conventional cash flow. i. e. when an initial cash outlays is followed by a series of cash inflows.
2. When the projects are independent of one another i.e., proposals the acceptance of which does not preclude the acceptance of others and if the firm is not facing a problem of funds constraint.

The reasons for similarity in results in the above cases are simple. In NPV method a proposal is accepted if NPV is positive. NPV will be positive only when the actual rate of return on investment is more than the cut off rate. In case of IRR method a proposal is accepted only when the IRR is higher than the cut off rate. Thus, both methods will give consistent results since the acceptance or rejection of the proposal under both of them is based on the actual return being higher than the required rate i.e.

NPV will be positive only if r > k, NPV will be negative only if r < k, NPV would be zero only if r = k

In the case more exactness is required another trial which is slightly higher than 10% (since at this rate the present value is more than initial investment) may be taken. Taking a rate of 12% the following results would emerge.

Year	Cash Inflows Rs.	Discounting Factor at 12.6%	Present Value Rs.
1	12,000	0.893	10,716
2	4,000	0.794	3,188
3	2,000	0.712	1,424
4	10,000	0.636	6,380
			21,688
Less:	Initial Investment Value		22,000
	Net Present Value		(–)312

$$\text{IRR} = \text{Base factor} + \frac{\text{Positive net present value}}{\text{Difference in positive and Negative net present value}} \times \text{DP}$$

$$\text{Base factor} = 10\%$$

$$\text{DP} = 2\%$$

IRR

$$= 10\% + \frac{544}{544 - (-312)} \times 2\%$$

$$= 10\% + \frac{544}{856} \times 2$$

$$= 10 + 1.27$$

$$= 11.27\%$$

Project B

Year	Cash Inflows Rs.	Discount Factor at 15%	Present value Rs.
1	2,000	0.909#	1,818
2	2,000	0.826	1,652
3	4,000	0.751	3,004
4	20,000	0.683	13,660
		Total present value	20,134
Less:		Initial investment	20,000
		Net present value	134

$$\text{IRR} = 10\% \frac{134}{134-(2676)} \times 5\%$$

$$= 10\% + 0.24\% \qquad \text{IRR} = 10.24\%$$

Thus, internal rate of return in project 'A' is higher as compared to project 'B'. Therefore project 'A' is preferable.

Mutually Exclusive Projects:

NPV and IRR methods may give conflicting results in case of mutually exclusive projects i.e. projects where acceptance of one would result in non-acceptance of other. Such conflicts of results may be due to any one or more of the following reasons.

1. The projects require different cash outlays.
2. The projects have unequal lives.
3. The project has different patterns of cash flows.

Let us understand each of the above mentioned reasons in detail for conflicting ranking of the projects using NPV and IRR.

(1) Different Net Cash Outlay:

When the cash outlays required for different projects are of different size altogether, these two methods (NPV & IRR) may give conflicting results. For example, if we calculate NPV and IRR for the following two projects X and Y, Project X's NPV at 10% discount rate is Rs. 4450.79 and IRR is 28%. Project Y's NPV at 10% minimum required rate of return is Rs. 24,372.65 and IRR is 17%. If we calculate IRR using incremental approach, it is 16% which is higher than the 10% discount rate of the project. Therefore, Project Y should be selected.

Project	C_0 (Rs.)	C_1 (Rs.)	C_2 (Rs.)	C_3 (Rs.)	NPV @ 10%(Rs.)	IRR (%)
X	(16000)	12000	7000	5000	4,450.79	28%
Y	(160000)	40000	70000	120000	24,372.65	17%
Y-X	(144000)	28000	63000	115000	19,921.86	16%

(2) *Unequal Lives of the Projects*:

When the two mutually exclusive projects are having different life spans, we may get conflicting results using NPV and IRR method. For example, in the following two projects IRR is higher for project A while NPV is higher for project B. Thus, both the projects give different ranking.

Years	C_0	C_1	C_2	C_3	C_4	NPV @10%	IRR
Project - A	(25,000)	30,000	0	0	0	2,273	20%
Project - B	(25,000)	0	0	0	43,750	4,882	15%

(3) *Different Pattern of Cash flows*:

When the projects under consideration are having different pattern of cash inflow it may give conflicting ranking of the projects under NPV and IRR. For example, Projects X and Y are having following pattern of cash flows:

Project	C_0	C_1	C_2	C_3	NPV @ 10%	IRR (%)
	(Rs.)	(Rs.)	(Rs.)	(Rs.)	(Rs.)	
X	(16000)	(12000)	7000	2000	2,196.84	20%
Y	(16000)	4000	8000	12000	3,263.71	19%
Y-X	**0**	**-8000**	**1000**	**10000**	**1,066.87**	**18%**

Project Y has higher NPV at 10% cost of capital but the IRR of Project X is higher than Project Y. It means there is conflict in ranking between these two projects for selecting projects using NPV and IRR.

Discount rate	Project X NPV	Project Y NPV
(%)	(Rs)	(Rs)
0	6,191	8000
5	4,631	5432
10	**3,264**	**3264**
15	2,057	1418
20	984	(167)
25	26	(1536)
30	(835)	(2727)

We can use incremental approach to select among mutually exclusive projects using IRR method. The IRR of incremental cash flows is 18% which is higher than our cost of capital 10%. Thus, Project Y can be accepted though it has IRR lower than Project X because it offers all the benefits of Project X at the same time IRR greater than cost of capital (i.e. 18% >10%).

Profitability Index (PI)

Profitability Index (PI) or Benefit-cost ratio (B/C) is similar to the NPV approach. PI approach measures the present value of returns per rupee invested. It is observed in shortcoming of NPV that, being an absolute measure, it is not a reliable method to evaluate projects requiring different initial investments. The PI method provides solution to this kind of problem.

It is a relative measure and can be defined as the ratio which is obtained by dividing the present value of future cash inflows by the present value of cash outlays. Mathematically

Profitability Index = PV of future cash inflows/ PV of cash outlays

This method is also known as B/C ratio because numerator measures benefits & denominator cost.

Decision Rule

Accept the project when PI>1; Reject the project when PI<1; May or may not accept when PI =1, the firm is indifferent to the project. When PI is greater than, equal to or less than 1, NPV is greater than, equal to or less than 0 respectively. The selection of the project with the PI method can also be done on the basis of ranking. The highest rank will be given to the project with the highest PI, followed by the others in the same order.

Merits

1. PI considers the time value of money as well as all the cash flows generated by the project.

2. At times it is a better evaluation technique than NPV in a situation of capital rationing especially. For instance, two projects may have the same NPV of Rs. 20,000 but project A requires an initial investment of Rs. 1, 00,000 whereas B requires only Rs. 50,000. The NPV method will give identical ranking to both projects, whereas PI will suggest project B should be preferred. Thus PI is better than NPV method as former evaluating the worth of projects in terms of their relative rather than absolute magnitude.
3. It is consistent with the shareholders' wealth maximization.

Demerits

1. When cash outflow occurs beyond the current period, the PI is unsuitable as a selection criterion.
2. It requires estimation of cash flows with accuracy which is very difficult under ever changing world.
3. When the projects are mutually exclusive and it has different cash outlays, different cash flow pattern or unequal lives, it may not give unambiguous results.

One major demerit of NPV method is that it cannot be applied to compare those mutually exclusive projects which differ in costs substantially. To compare and evaluate such projects, the profitability index should be calculated. It can be calculated in two manners:

$$\text{(i)} \quad \text{Gross BCR} = \frac{\text{Total Present Values of Cash Inflows}}{\text{Intial Investment}}$$

$$\text{(ii)} \quad \text{Net BCR} = \frac{\text{Net Present Values of Cash Inflows}}{\text{Intial Investment}}$$

Example 12: To illustrate the calculation of these measures, let us consider a project which is being evaluated by a firm that has a cost of capital of 12 per cent.

Initial investment	Rs. 100000
Year 1	25,000
Year 2	40,000
Year 3	40,000
Year 4	50,000

The profitability index for this project is:

$$PI = \frac{\frac{25,000}{(1.12)1} + \frac{40,000}{(1.12)2} + \frac{40,000}{(1.12)3} + \frac{50,000}{(1.12)4}}{1,00,000} = 1.145$$

As here PI is greater than one we accept the project because we are getting a rate of return which exceeds our desired rate of return.

Example 13: Determine profitability index and net present value assuming discounting factor as 10%.

Cash flows are multiplied with the present value factor of the corresponding year to calculate present value for the year. The sum total of all negative and positive present value is net present value. The ratio of positive and negative cash flow is profitability index.

Year	Cash flow	PVF (10%)	PV
0	-160	1	-160
1	30	0.9091	27.27
2	40	0.8264	33.06
3	50	0.7513	37.57
4	60	0.6830	40.98
5	100	0.6209	62.09
Total			**40.97**

Profitability index = 200.97/160 = 1.256

Net present value (NPV) = 200.97 – 160 = 40.97

Decision: Project is accepted at 10% discounting as PI is greater than one and NPV is positive.

Time Value of Money

The value of money received today is more than the value of money received after some time in the future due to the following reasons:

(i) Inflation: Under inflationary conditions the value of money expressed in terms of its purchasing power over goods and services declines.
(ii) Risk: Having one rupee now is certain where as one rupee receivable tomorrow is less certain. That is a bird-in the-hand principle is most important in the investment decisions.
(iii) Personal Consumption Preference: Many individuals have a strong preference for immediate rather than delayed consumption. The promise of a bowl of rice next week counts for little to the starving man.

Present Value: The value of a firm depends upon the net cash inflows generated by the firm assets and also on future returns. The amount of cash inflows and risk associated with the uncertainty of future returns forms the basis of valuation. To get the present value, cash inflows are to be discounted at the required rate of return i.e., minimum rate expected by the investor to account for their timing and risk.

CASE STUDY (Example 14): A chemical company is considering replacing an existing machine with one costing Rs 65,000. The existing machine was originally purchased two years ago for Rs 28,000 and is being depreciated by the straight line method over its seven-year life period. It can currently be sold for Rs 30,000 with no removal costs. The new machine would cost Rs 10,000 to install and would be depreciate over five years. The management believes that the new machine would have a salvage value of Rs 5,000 at the end of year 5. The management also estimates an increase in net working capital requirement of Rs 10,000 as a result of expanded operations with the new machine. The firm is taxed at a rate of 55% on normal income and 30% on capital gains. The company's expected after-tax profits for next 5 years with existing machine and with new machine are given as follows:

	Expected after-tax profits	
Year	With existing machine (₹)	With new machine (₹)
1	2,00,000	2,16,000
2	1,50,000	1,50,000
3	1,80,000	2,00,000
4	2,10,000	2,40,000
5	2,20,000	2,30,000

a) Calculate the net investment required by the new machine.
b) If the company's cost of capital is 15%, determine whether the new machine should be purchased.

Appraisal of replacement decision under NPV method
Step 1:

Calculation of present value of net investment required:	(₹)	(₹)
Cost of new asset		65,000
Add: Installation cost		10,000
		75,000
Add: Additional WC		10,000
		85,000
Less: Sale proceeds of old machine	30,000	
Less: Tax [8,000 x 55/100 + 2000 x 30/100]	5,000	25,000
Net Investment required		60,000

Step 2: Calculation of Present Value of Incremental Operating cash inflows for 5 years.

Year	CIAT (PAT + Dep)	New	Incremental	PV factor at 15%	Present Value
1	2,04,000	2,30,000	26,000	0.8696	22,609
2	1,54,000	1,64,000	10,000	0.7561	7,561
3	1,84,000	2,14,000	30,000	0.6575	19,725
4	2,14,000	2,54,000	40,000	0.5718	22,872
5	2,24,000	2,44,000	20,000	0.4972	9,944
PV of cash inflows for 5 years					82,711

Step 3: Calculation of PV of terminal cash inflow

	(₹)
Salvage value of asset [No tax because book value and salvage value are equal]	5,000
Working capital recovered [100% recovered]	10,000
Terminal cash inflows	15,000

It's PV at the end of 5th year = 15,000 x 0.4972 = 7,458

Step 4: Calculation of NPV `

PV of total cash inflows [82,711 + 7,458] = 90,169
(–) Outflow = 60,000
NPV = 30,169

Comment: As NPV is positive, it is advised to replace.

Note 1:

Depreciation for old Machine = 28,000 / 7 = Rs 4,000
Depreciation for new Machine = (65,000 + 10,000 - 5,000)/5= Rs 14,000

SPACE Analysis

(Strategic Position and ACtion Evaluation)

Debayan Nandi

SPACE Analysis is an analytical technique used in strategic management and planning. SPACE is an acronym of Strategic Position and ACtion Evaluation. The analysis allows to create an idea of the appropriate business strategy for the enterprise. The analysis assesses the internal and external environment and allows to design an appropriate strategy.

The analysis describes the external environment using two criteria:

- **Environmental Stability** (ES) - it is influenced by the following subfactors: technological change, inflation rate, demand volatility, price range of competitive products, price elasticity of demand, pressure from the substitutes
- **Industry Attractiveness** (IA) - it is influenced by the following subfactors: growth potential, profit potential, financial stability, resource utilization, complexity of entering the industry, labor productivity, capacity utilization, bargaining power of manufacturers

The inside environment is also described by two criteria:

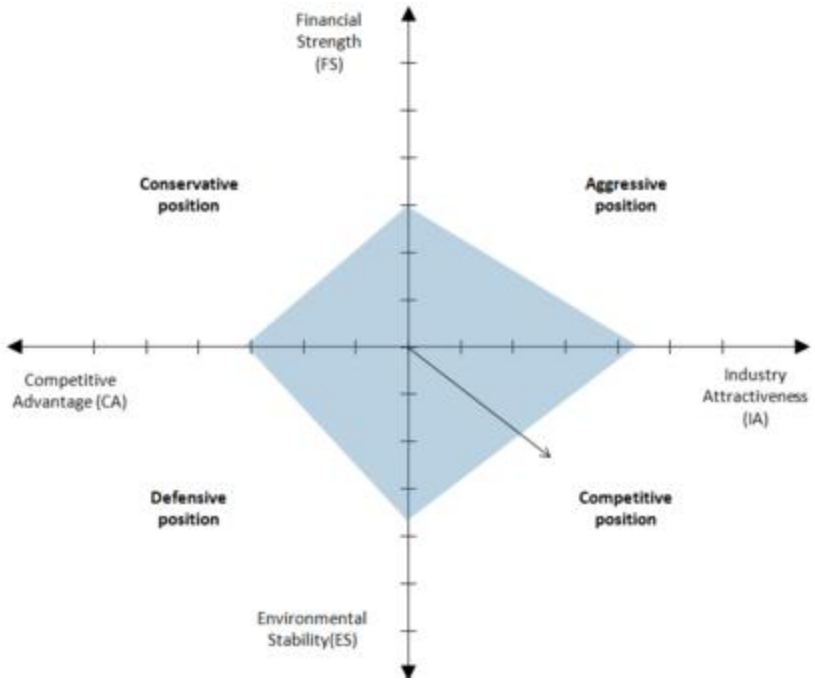
- **Competitive advantage** (CA) - it is influenced by the following factors: market share, product quality, product lifecycle, innovation cycle, customer loyalty, vertical integration
- **Financial strength** (FS) - it is influenced by the following indicators: return on investment, liquidity, debt ratio, available versus required capital, cash flow, inventory turnover

How to use the SPACE analysis in practice?

According to this model the SPACE analysis is used in strategic management. It concerns of key decisions that are made by CEO and senior management of the organization.

To evaluate:

- For each subfactor in each criterion a value of 0-6 is assigned (for CA and ES it is 0 to -6)
- For each criterion, the value of the total factor is expressed as the mean of the individual factors.
- The values of factors are put into the relevant axes of the matrix (see figure)
- In the quadrant, where the largest part of the surface of the resulting quadrilateral is, there is a suitable altermative of the business behavior.



The strategic position of the company and alernatives of the strategic behavior are following:

- **Aggressive position** - an attractive and relatively stable industry, the company has a competitive advantage and it can protect it, a critical factor is the possible entry of new competitors into the industry, it may be considered new acquisitions, increasing market share and focusing on competitive products
- **Competitive position** - attractive and relatively unstable environment, the company has some competitive advantage, a critical factor is the company's financial strength - the company should look for ways of their attachment, the solution is the possibility of joining another company, increasing production efficiency and strengthening cash flow
- **Conservative position** - a stable industry with low growth rate and financially stable company, a critical factor is in the product competitiveness, company should protect its succesfull products and develop new ones and think about the possibilities of the penetration into the industry more attractive and reduce costs.
- **Defensive position** - an unattractive industry, the company lacks competitive products and financial resources, a critical factor is the competitiveness, the company should reduce costs, reduce investment and consider leaving the industry.

Strategic Choice Approach

A repetitive technique used for complex problems and their sub-problems, consisting of 4 basic principles

- **Shaping**, involves identifying the problem areas
- **Designing**, recognising what can be done, looking at possibilities and drawbacks.
- **Comparing**, various ideas, evaluating the best possible way forward
- **Choosing**, the best ideas for solving the problems. Compiling a plan of action, acknowledging any uncertainties.

Strategic Choice in Negotiation

Dean Pruitt

Dean Pruitt, "Strategic Choice in Negotiation," in Negotiation Theory and Practice, eds. J. William Breslin and Jeffery Z. Rubin, (Cambridge: The Program on Negotiation at Harvard Law School, 1991),.

Pruitt discusses four basic negotiation strategies, factors which affect the choice of strategy, and how the choice of strategy affects the negotiation's outcome.

Negotiation Strategies

There are four basic negotiation strategies. They are: problem solving, contending, yielding , and inaction. Problem solving seeks to reconcile the parties' aspirations. Problem solving tactics include increasing available resources, compensation, exchanging concessions on low priority issues, minimizing the costs of concessions, and creating new mutually beneficial options. The advantage of problem solving strategies is that they yield the, best outcomes. Mutually beneficial outcomes are more likely to last, to improve the parties relationship, and to benefit the wider society. Problem solving outcomes are likely to benefit both parties when the situation has

high integrative potential and both parties have reasonably high aspirations. In addition parties must be firm about their aspirations or goals, but must be flexible regarding the means used to reach those goals. The risk of problem solving strategies is that they may backfire if the other side pursues a contentious strategy.

Contention seeks to persuade the other party to agree to a solution that favors one's own interests. This strategy has also been called positional bargaining. Contentious tactics include inflated demands, irrevocable commitments, persuasion, and threats. Contentious strategies alone tend to yield poor outcomes. Contending may escalate a conflict. When outcomes are finally reached they may be low-level compromises. Contention is often used as an opening strategy, to be replaced by problem solving at a later stage. In such cases the early use of contention may still yield beneficial outcomes.

When parties yield they reduce their aspirations. Yielding is an effective way to close negotiations when issues are unimportant and time pressures are high. Yielding can also contribute to a successful problem solving approach. However, outcomes tend to be depressed when both parties use a yielding strategy. The strategy of inaction is usually used to increase time pressure on the other party.

Choosing a Negotiation Strategy

Pruitt offers two models of negotiation strategy choice: the dual concern model, and the feasibility model. The dual concern model predicts strategy choice based on four factors. "Concern about both one's own and other party's outcomes encourages a problem-solving strategy; concern about only one's own outcomes encourages contending; concern about only the other party's outcomes encourages yielding; concern about neither party's outcomes encourages inaction."

Concern about one's own outcome is increased by the importance of the issues involved. Concern is also increased when one's aspirations are close to one's baseline position, that is, when there is little room to make concessions. Concern is diminished when one fears conflict. Research has found that representatives are more concerned and less likely to yield than are individuals negotiating on their own behalf. This is because

representatives are accountable to and need the approval of their constituents.

Concern about the other party's outcome may be genuine or strategic. Genuine concern for the other is increased by personal attraction, shared group identity, or a positive mood. Strategic concern for the other's outcomes results from dependency on the other, or when the other can supply rewards or penalties.

Experimental studies have confirmed the model's predictions. Studies also show that concern for the other party's outcome leads to problem solving strategies and is most beneficial when combined with concern for each party's own outcome. Lower interest in one's own outcome results in yielding and low joint benefits. Representative accountability tends to encourage contention. However, representative accountability can promote problem solving if conditions also encourage a good relation between the negotiators.

Feasibility also affects the choice of negotiation strategy. "A strategy is seen as feasible to the extent that it seems capable of achieving the concerns that give rise to it."[p. 35] Even though a strategy is favored by the dual concern model, it will not be employed if it is not also seen as feasible.

The feasibility of problem solving strategies depends on the amount of the parties' perceived common ground (PCG), that is, how likely it seems that the parties will find a mutually satisfactory solution. The PCG is greater when the parties' aspirations are low, and their confidence in their creativity and ingenuity is high. Pruitt points out four factors which increase the parties' PCG. First is their confidence in their own problem solving skills. Second is the presence of problem solving momentum from previous successful negotiations. Third is the presence of a mediator. Mediators facilitate the parties' problem solving and communication activities, and actively search for common ground. Fourth is the presence of trust on the part of at least one of the parties. When the trusted party also has firm aspirations, the other party will generally adopt a problem solving strategy. When the trusted party's aspirations seem weak, the other party will adopt a contentious strategy, expecting the trusted party to yield.

Contending seems more feasible when the other party's concern for their own outcome is low, that is, when their resistance to yielding is low. Pruitt

argues that contention is a self- limiting strategy. The strategy tends to be abandoned if it fails. Successful contention moves the losing party closer to their baseline position, and so tends to increase their resistance to further yielding. Thus further contention becomes less feasible. The costs of contending must also be taken into account when considering the feasibility of that strategy. Costs include possibly escalating the conflict, and provoking censure from third parties or constituents.

Inaction generally increases the time pressure on the parties. Yielding is the most common response to time pressure. Thus inaction is a feasible strategy when the other party is more susceptible to time pressure than the inactive party and when their resistance to yielding is low.

Influencing the Other Party's Strategy

Since joint problem solving yields the most beneficial outcomes, it is in a party's interests to encourage the other to adopt a problem solving approach. One way to do this is to encourage the other to develop concern for one's own outcomes. This may be done by offering favors to the other and cultivating their dependence, by pointing out a common identity, or by putting them in a good mood. Another way is to explicitly adopt a problem solving approach coupled with firmness about one's interests and aspirations, and flexibility about the means of satisfying those aspirations. Pruitt explains that "the firm part of this strategy should convince the other that contentious behavior is infeasible, that one will never give under pressure. The conciliatory and flexible parts should produce enough PCG and trust that the other will see problem solving as thoroughly feasible."[p. 42] Firmness in one's aspirations may be conveyed by strong statements and verbal defenses. Contentious tactics may be used to underscore one's commitment. However, parties must be careful in the use of such tactics, lest they undermine the greater problem solving approach. Flexibility in the means of reaching an outcome and the form of the outcome may be conveyed by showing concern for the other's interests and willingness to try to satisfy them, by open communication, by demonstrations of one's problem solving skills, and by a willingness to re-evaluate the importance of interests that are clearly unacceptable to the other side.

Is faces a strategic choice regarding systems development : get good or get out.

The preceding messages suggest that the year 2000 problem is proving to be the ultimate test of whether an IS department should be in the business of building systems or not. There are four available options. Two entail getting out of systems development: outsource the process to an organization with the scale and competence to handle these challenges, or adopt a package-only strategy. The third option is to keep development in-house and build first-class processes for systems maintenance, renewal, and change-programme management. The fourth option is to invest in an architecture and infrastructure that explicitly supports unforeseen business change. Though this is undoubtedly the rarest strategy, Foundation research has shown it to be the most powerful.

Most important of all, ensure that both the business and the IS department fully understand the advantages and risks of each before making that strategic choice.

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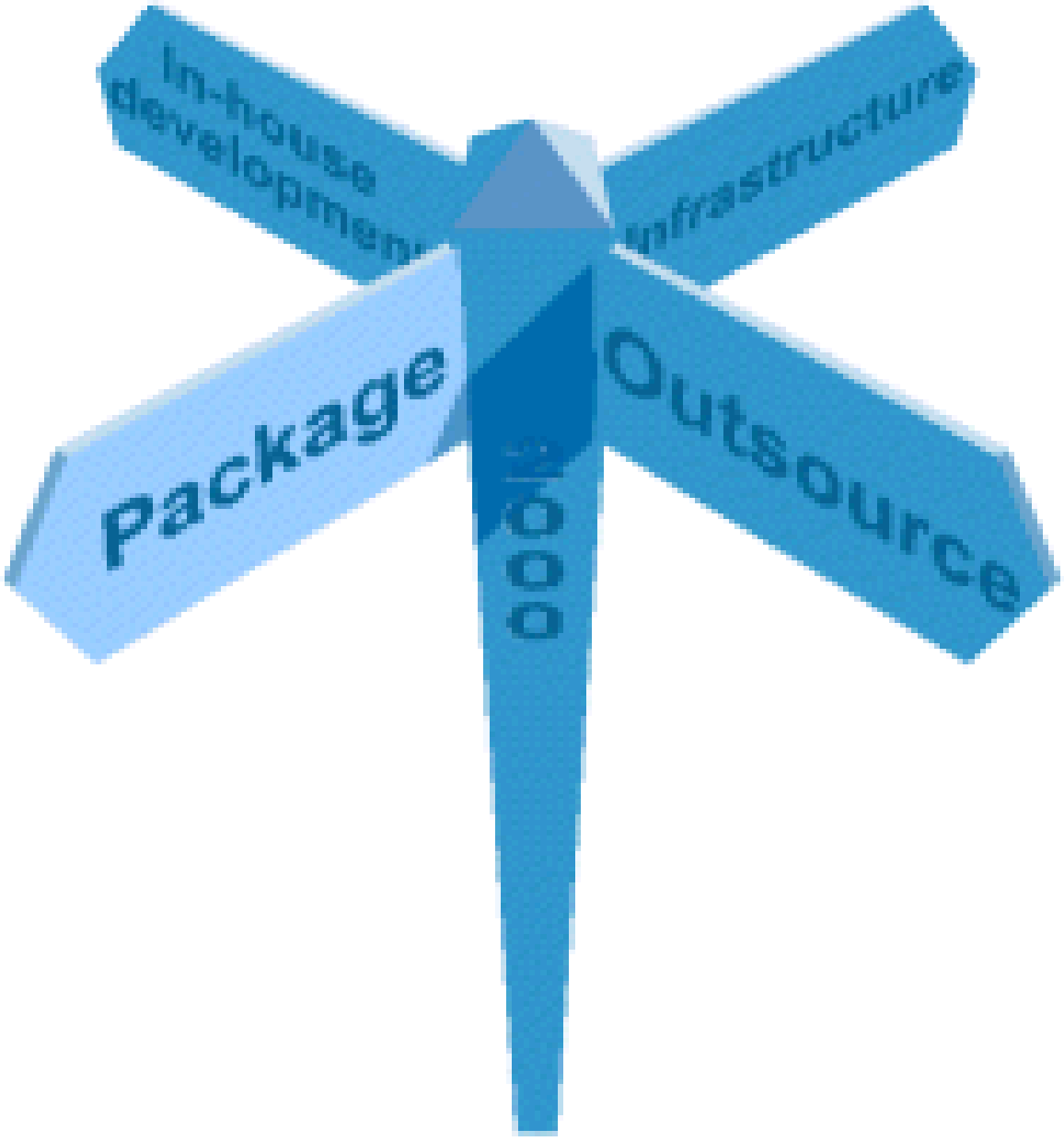
STRATEGIC CHOICES

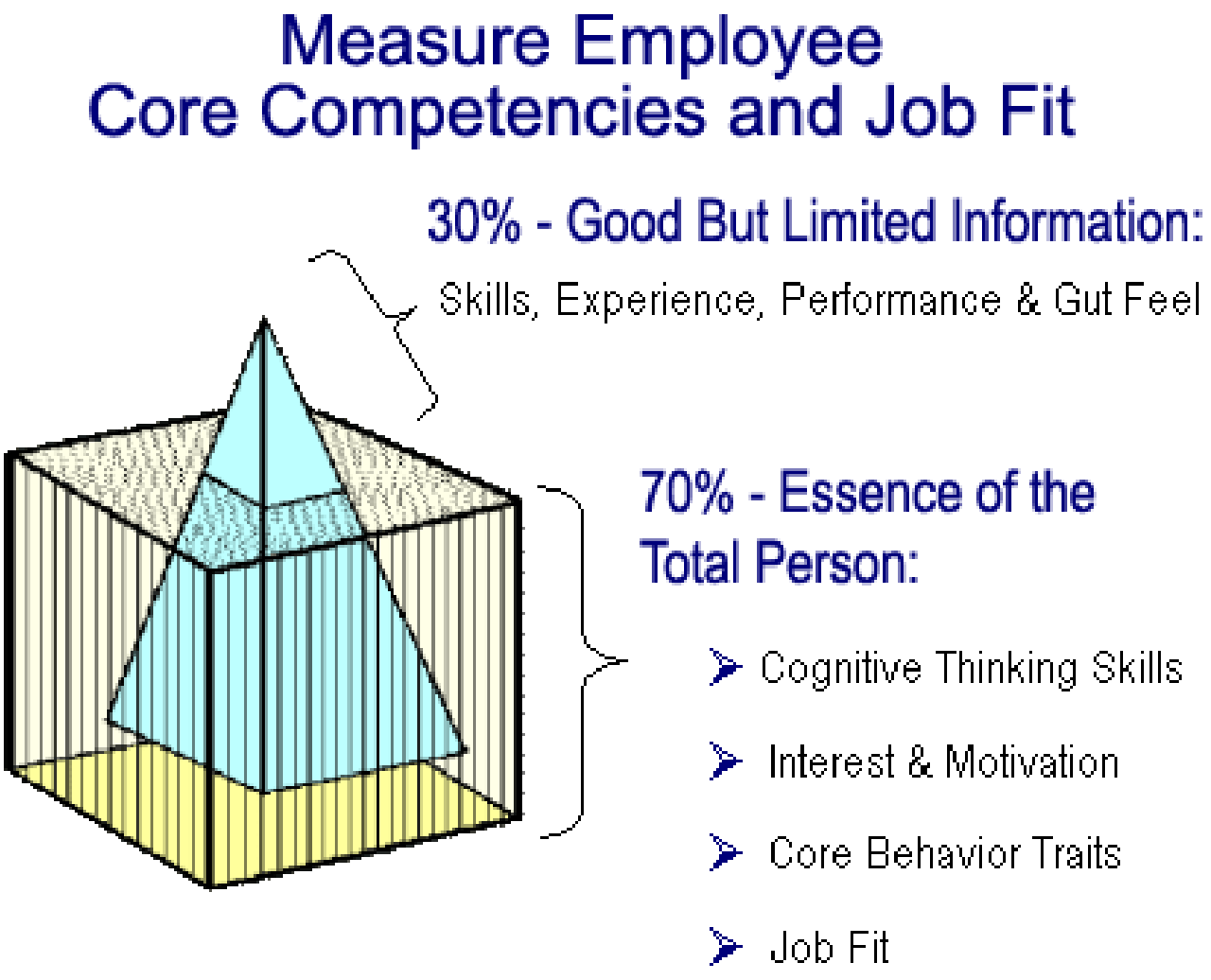

In-house
Package
Outsource

A Succession Planning System to Identify and Develop your Future Leaders!

If you believe in promoting from within your organization we have the system for you! The ProfileXT Assessment will identify employees who are upwardly mobile and what positions to prepare them for. Checkpoint Feedback will chart their development, initiate self development plans and measure progress in key skill sets! The ProfileXT is customized to reflect core competencies of current top performers in your company!

First Identify your Upwardly Mobile Employees with ProfileXT

- Who has the ability and desire to go to the next level and beyond!
- A competency gap analysis with behavioral interview questions!
- Let you see the Peter Principle and avoid it!
- Coaching, development and training tips for managers and trainers!
- Individual Tips for each person!



Succession Planning & Management

It is Critical to Ensure Leadership Continuity by Building Competitive Capability From Within!

Businesses that don't take proactive steps to plan for future talent needs at all level using their entire diverse work force will face certain disruptions, heavy financial costs, and even disasters, when key employees retire or are lured away by competitors. Current research shows that on average, replacing 10 professional employees costs $1.2 Million! Replacing hourly employees can easily cost the equivalent of 6 months salary and benefits! Hubbard & Hubbard, Inc. has the research numbers which prove it!

It doesn't matter whether you are a for profit, non-profit, government, or any other kind of organization, ***retention of high-caliber employees is a critical key to competitive success*** and turnover a continual constraint on organizational growth. "Intellectual Capital" is truly an organizational asset. A major asset!

Hubbard & Hubbard, Inc. can provide an in-depth, complete succession planning system to help you **build, revitalize, or evaluate** your succession planning efforts. We can assist you with the electronic software, self-assessments, organizational analysis, measurement systems, and other tools necessary to give you the confidence you need to more accurately gauge your succession planning process.

Our processes offer proven, step-by-step approaches to succession planning that allow you to:

- Identify core technical and behavioral competencies essential to organizational performance
- Identify competencies and clarify values for planning and managing a succession process.
- Develop systems to plan for and quickly fill crucial vacancies at all levels
- Calculate the cost of poor succession management and its organizational impact
- Develop strategic executive and management coaching and mentoring competencies
- Apply methods to develop and retain top talent that builds and preserves your organization's intellectual capital

- Assess current and future resources for seamless succession planning
- Integrate these processes into your current operating environment with minimal disruption
- Use online, web-based and other technology tools to organize and implement your succession planning process
- Measure the impact and success of your succession planning efforts in dollars and cents!

We can help you effectively work through each stage of our human capital continuity process...

The Effective Performance and Succession Process

- **Gaining Buy-In**
- **Interviews and Analysis**
- **Objective setting Workshop**
- **Competency and Values Clarification**
- **The Business Case for Change**
- **Setting Up an Effective Succession Planning & Management Process**
- **Assessing Present Work Requirements and Job Performance**
- **Assessing Future Work Requirements and Individual Potential**
- **Developing Internal Successors**
- **Assessing Alternatives to Internal Development**
- **Applying Online and High Tech Approaches to the Succession Planning Process**
- **Measuring and Evaluating Succession Plan Impact and Performance**
- **Refining the Process**

Succession Planning Process :-

1. First Meeting

- Discuss the whole concept and rationale for succession planning
- Identify & agree on "key" (management or knowledge) positions. Form to complete: key management and/or knowledge base list
- Each "key" individual identifies & lists three (if possible) potential replacements/successors (in order of likeliness) for their own position
- Prior to next meeting - potential successors should also be assigned a "readiness" rating.

2. Second Meeting

- Each individual shares their list with group and gets input/additional suggestions from group
- Individuals in key positions look at their list of potential successors and suggest 2-3 developmental experiences that would increase the individual's readiness for the position -- the group should discuss the back-up individuals on each list, the readiness ratings and developmental needs with the thought in mind that succession plans might change.

3. Compile Final List

- Someone such as HR or a Deputy (who should this be?)compiles a final list.
- The Identified developmental needs are forwarded to the employee's supervisor to be incorporated into the Performance Planning Process.

4. Annual Review

- The entire process is repeated 1-2 times per year with the idea that names, readiness ratings and developmental needs on any individual succession plan might change based on new data, position changes within the organization, different individual's performance and professional growth, the cumulative experience of the group working on the process.

General Principles of Redeployment

A) A primary aim of management in the Northern Ireland Civil Service will be to ensure the absorption of surplus staff by means of redeployment either to other suitable posts in the same Department - insofar as this is possible - or in another Department. The employing Department, therefore, will be responsible, initially, for making every effort to absorb its own surplus staff or to place them in other Departments; only when these measures have been exhausted can a formal surplus be declared (to Conditions of Service and Employee Relations Division, DFP).

B) When formal surpluses have been declared, the redeployment and placement of the staff concerned will take precedence over all recruitment (including reinstatements), transfers and promotions, as well as the employment of casual staff. To ensure that surplus staff are redeployed and placed in other suitable posts as quickly as possible, the suspension of open recruitment and/or promotion (including temporary promotion) may have to be instituted in either the short or long term, depending on the circumstances. However, in instances where the Northern Ireland Civil Service Commission has already issued offers of appointment, action on these will be completed before open recruitment competitions are suspended.

C) Occasions may arise when it might be necessary to suspend internal transfers of staff as well as the operation of the Central Transfer List. In the latter case, particular attention will be paid to the claims of those with W1 welfare ratings. Further, while surpluses exist, non-compassionate transfers from the Home Civil Service will not, as a rule, be permitted but compassionate cases will be judged on the same basis as W1 cases.

D) In addition to redeployment elsewhere within the same discipline, staff who are declared surplus may also be considered for placement in another suitable discipline: provided the normal rules are satisfied this can be effected by means of: (i) level transfers; (ii) lateral movement - although in practice the scope for this may be very restricted; and (iii), the Sideways Transfer Scheme, if applicable.

E) It follows that surplus members of staff who move to another discipline or to the General Service via any of these measures will be given precedence over new entrants. However, in the event of unexpected surpluses arising in the discipline to which they are moving, no transfers can take place until these surplus staff have been absorbed and the surpluses cleared.

F) Officers who consider that a particular posting may have a detrimental effect on their personal circumstances have the right of an interview with their Personnel/Career Development Officer to discuss the posting.

G) Staff considered unsuitable for either (i), (ii) or (iii) of paragraph 4 above and who cannot be redeployed in their own discipline/specialization will be dealt with in accordance with the pre-redundancy procedures set out in paragraph 12 and 13 below. The normal rules relating to starting pay on transfer to a new substantive grade will apply unless particular circumstances allow pay to be held on a mark-time basis.

H) In a surplus situation it will not necessarily be those whose posts are to disappear who will be put forward for transfer, nor will the "last in - first out" principle be the only determining factor. In certain circumstances ie, in advance of a surplus being declared, early consideration may be given to inviting volunteers for transfer. In such instances Departments will make arrangements to ascertain from staff their preference as regards locations and types of work; where these clash, preference should be given to locating an individual in an area of his/her choice. Whilst everything possible will be done to ensure that the wishes of staff are taken into account it may not always be possible to accommodate them.

I) Releasing Departments will make staff available for absorption into other Departments from as broad a spectrum of ages and ability-ranges as possible. Departments cannot refuse to take an individual unless unsuitability for a particular vacancy can be demonstrated. When staffs have been allocated to a new Department

they should be released with minimum delay.

J) Additionally, when a surplus has been declared importing Departments may, where appropriate, and following consideration of cases listed on the CTL, advertise vacancies through interest circulars and invite applications from staff with the necessary competences from the surplus grade to apply.

K) Redeployment to another Department will not result in an officer's name being removed from a promotion list in his/her former Department. An officer will, therefore, be considered for promotion to vacancies in his/her former Department for the duration of the life of the list on which his/her name appears. This rule is subject to the operation of the normal rules for promotion and will not affect an officer's right to be considered for promotion in the new Department.

L) In a redeployment situation it is possible that some Departments may have to take a larger proportion of surplus staff than others but the aim will always be to achieve an equitable distribution of the surpluses. As far as practicable, account will be taken of the implications of redeployment for equality of promotion opportunity.

M)Even after allowing for the operation of the redeployment rules, it cannot be guaranteed that there will be no redundancies. For example, where surpluses occur at small locations, or in specialist disciplines where there is no foreseen scope for redeployment, pre-redundancy measures such as early retirement or early severance may be applicable. In the event of redundancies being unavoidable, the procedures set out in Chapter 6 must be followed.

N) In such instances, Conditions of Service and Employee Relations Division, DFP should be notified and Departmental TUS consulted about the unit to be targeted. The agreement of Conditions of Service and Employee Relations Division, DFP will also be required for early retirement/severance schemes. Where grades other than departmental grades are involved viz, General Service or grades common to several Departments, Conditions of Service and Employee Relations Division will consult with Central TUS about the unit to be targeted.

O) A mobile officer will be declared redundant only if there is no suitable post for him/her anywhere in the Northern Ireland Civil Service. A non-mobile officer will be declared redundant only if there is no suitable post available within reasonable daily traveling distance of his/her home either in the same or in another Department. As in the case of early retirement, Departments should not initiate redundancy procedures without first consulting Conditions of Service and Employee Relations Division. In any redundancy situation, Chapter 6 will apply.

P) Departmental and Central Trade Union Sides will be kept informed about staff surplus situations on an ongoing basis.

Redeployment Procedure :-

1) Departments will observe the following procedures in connection with the redeployment of surplus staff:-

i.) Conditions of Service and Employee Relations Division, organization must be notified as early as possible of any impending formal surpluses .

ii.) At the same time, Departments must advise the respective Establishment/Personnel Divisions of the other Departments that employ staff in the grades concerned in order to match the officers with suitable existing or anticipated vacancies; and

iii.) Conditions of Service and Employee Relations Division will maintain a central register containing details of staff surpluses on a Service-wide basis.

2) In the event of problems arising from surpluses in the grades of Staff Officer and above, including analogous grades, it may be necessary to convene special meetings of Establishment Officers/Personnel Officers. In such circumstances the meeting will be called and chaired by a member of Conditions of Service and Employee Relations Division.

3) In addition, an Interdepartmental Group consisting of representatives from departmental Establishment/Personnel Divisions will meet twice yearly or as required to discuss arrangements for the redeployment of staff in the grades of Grade 6 and below, including analogous grades. This forum will also be chaired by a representative from Conditions of Service and Employee Relations Division.

UNIVERSITY OF GLASGOW

MANAGEMENT OF ORGANISATIONAL CHANGE POLICY & PROTOCOL

REDEPLOYMENT GUIDANCE NOTES

Introduction

Meaning : - Where a redeployment of employees becomes necessary on account of a reorganization of production, modernization of equipment of the expansion of an enterprise, such redeployment should be effected with minimum hardship for , and discomfiture of , the affected employees. There should be no reduction in remuneration for anyone. If, n redeployment, employees need further training, that should be arranged at the employer's cost.

Following the introduction of the Management of Organisational Change Policy: Avoidance and Mitigation of Redundancy and the Management of Compulsory Redundancy Protocol, the University is strengthening its active commitment to seek to fully explore the scope to redeploy staff who are actually or potentially redundant.

Staff eligible for such support will be:

- Staff volunteering for redeployment;
- Staff whose posts have been formally identified as provisionally redundant (eg. Staff who are 'at risk' having been advised of the potential for their redundancy through the redundancy consultation process); or
- Staff who have received formal notice of redundancy (referred to hereafter as staff who are "actually redundant").

In this context, the expiry of a fixed term contract is generally on the grounds of redundancy and accordingly such staff will be included within these processes. The redeployment procedure seeks to ensure that eligible staff are fully assisted to enable them to obtain suitable alternative posts within the University in order to avoid redundancies.

In seeking to provide suitable alternative employment, consideration will be given to the comparability of the new position with that previously held in terms of grade, rate of pay, hours of work, location and working environment. Given that exact matches may not be possible, flexibility and an open-minded approach will therefore be necessary from both

the members of staff and management concerned. No available post should be dismissed from consideration for redeployment solely on the basis that it is at a lower/higher grade or salary than that held by any provisionally or actually redundant member of staff.

These guidance notes are intended to outline the processes which will facilitate redeployment activities and to identify the roles that will be involved for the staff directly affected, line management and HR staff. For the purposes of this document, hereafter, members of staff who are identified as provisionally or actually redundant, or are volunteers for redeployment, will simply be referred to as the member(s) of staff.

Job Seekers' Register

To facilitate the redeployment process the University will use a Job Seekers' Register (JSR) to maintain the details of the affected members of staff. This will be maintained by the Human Resources Department. The JSR will hold a wide range of standardised information on the members of staff to enable assessment of their suitability for interview and or appointment to redeployment opportunities in the University.

Members of staff will be required to provide a summary CV in a standard electronic format identifying their key qualifications, membership of professional bodies, experience, transferable skills, academic publications, employment interests and contact details. The JSR will retain such information, together with details of grade, academic title (where relevant), department, and, where relevant, expected date of redundancy. The JSR will provide direct links to staff's current agreed job description (where electronically available) as well as their CV. Staff wishing assistance in completing the CV proforma should contact their line manager or territorial HR Manager.

Normally staff will be asked to provide their CV information and job descriptions at the start of the consultation process. The consultation commencement date will normally be one (1) month in advance of the issue of notice of redundancy, but will be determined taking account of both the number of staff provisionally proposed as redundant and the redundancy notice period required by contract and/or statute. In most cases consultation with trade unions and staff will be expected to commence four (4) months in advance of the proposed effective date of potential redundancy. This will facilitate a minimum period of one (1) month's consultation in advance of the maximum possible notice period of three (3) months. Thus in most cases staff will be asked to provide their CV information and job descriptions four (4) months in advance of the proposed effective date of potential redundancy. Occasionally staff may not be required to serve their full notice periods and accordingly a minimum consultation period of one month will normally be applicable. In these cases staff will normally be asked to provide their CV information and job descriptions one (1) month in advance of the proposed effective date of potential redundancy.

It is expected that early commencement of the consultation process will provide additionally for advance warning of the potential for redundancy, enable staff to consider the information they wish to supply in their CV within the standard format, enable job

descriptions to be updated and agreed as necessary, and in the case of fixed term appointments enable the early consideration of the financial options available to support the post(s) in question. This latter element is particularly relevant in the case of grant-funded appointments.

When consultation commences four (4) months in advance of the proposed effective date of potential redundancy, staff's details will automatically be entered onto the JSR three (3) months in advance of the potential redundancy date, unless internal financial clearance has already been received to continue the post(s). Where a consultation period of less than four (4) months is provided, staff's details will automatically be entered onto the JSR a minimum of one (1) month in advance of the potential redundancy date.

Redeployment Process

Prior to advertising vacancies, managers with vacancies will first be expected to consider all staff on the Job Seekers' Register to determine those who may satisfy the essential selection criteria for selection for interview for redeployment, or those who could satisfy these criteria with reasonable retraining. To assist in this process it will be advantageous to have consulted the territorial HR Manager to finalise the job and person specification for the vacancy prior to their use.

If having applied this procedure there is no interest in a vacancy or no appointable candidate, only then will the vacancy be advertised, internally and/or externally. It is expected that the redeployment selection process will normally be completed within 3 weeks.

Where it is unclear whether a member of staff could satisfy the essential selection criteria for selection for interview for redeployment, with or without retraining, the member of staff will be offered the opportunity for interview for redeployment regardless. A record will be kept of the reasons for selection or non-selection for interview for redeployment using the JSR Shortleet Assessment Form. The reasons for non-selection for interview will be reviewed by the territorial Human Resources Manager and provided to the member(s) of staff concerned.

Thus identified staff would be interviewed to review their suitability for appointment and required to submit a supporting letter of application (in addition to the CV and details supplied from the Job Seekers' Register) in respect of such vacancies prior to the interview. The supporting letter of application will outline the applicant's reasons they consider themselves a suitable match for the post for which they are to be interviewed. The redeployment interview panel will normally consist of the manager with the vacancy and a manager of similar seniority from a cognate department.

Following the interview:

- If the member of staff fully satisfies the essential selection criteria, s/he will be offered the opportunity to be redeployed to the new position, subject to a mutually

agreed trial period comprising the statutory four weeks' trial. This trial period can be extended prior to commencement by mutual agreement to a longer duration should it be considered practical and necessary for retraining purposes only;

- If the member of staff could fully satisfy the essential selection criteria with a reasonable level of retraining, the nature, extent and means for gaining such retraining will be agreed with the recruiting manager, member of staff and territorial Human Resources Manager. The member of staff will be offered the opportunity to be redeployed to the new position, subject to satisfactory completion of the agreed retraining and to a mutually agreed trial period inclusive of the statutory four week's trial. Again, this trial period can be extended prior to commencement by mutual agreement to a longer duration should it be considered practical and necessary for retraining purposes only;
- If the member of staff is unsuccessful at interview, written reasons will be provided to him/her indicating why an offer of the opportunity to be redeployed to this vacancy is not appropriate. The reasons for non-selection for redeployment will be reviewed by the territorial Human Resources Manager.

Terms of Redeployment

In the event of redeployment to a lower paid post, the member of staff's existing salary would be protected for a period of one year only. Protected existing salary will mean basic salary without overtime or other non-contractual payments. During the period of protection the protected salary will be 'frozen' and thus not attract incremental progression. Where the alternative employment is for different hours of work, either more or fewer than in the existing post, this will be taken into account in determining the extent of salary protection.

Where a new or renewed contract is offered it will not normally be appropriate for the University to seek to terminate a trial period prematurely. However, following appropriate consultation with the member of staff and the territorial Human Resources Manager, trial periods may be terminated by the University at any time during the period if the redeployment is not considered successful for reasons arising directly from the change in role. If a trial period is not terminated before its completion the redeployment to the post must be confirmed. The member of staff may terminate a trial period, following appropriate consultation, unconditionally on the grounds that it is considered unsuccessful. If the member of staff remains in post they will no longer be eligible for redundancy pay.

Any member of staff who has received formal notice of redundancy, who unreasonably declines an offer of suitable alternative employment or unreasonably terminates a trial period in that employment, will normally forfeit the right to redundancy pay.Staff who are redeployed will receive a written statement of the terms of their amended contract; continuity of service and service-related benefits will be protected. Staff accept as a condition of redeployment to undertake appropriate retraining as deemed necessary by the University.

Appeal Rights

Where there is a dispute over the reasons for non-selection for interview or redeployment, or the suitability of alternative employment, or whether a trial period was terminated unreasonably, the matter will be reviewed by the territorial Vice-Principal together with a Human Resources Manager not previously involved upon the written submission from the relevant member of staff or manager as appropriate.

Role of Managers in Redeployment process :-

Within the redeployment process managers have two key roles, either as the manager with the provisionally or actually redundant member of staff, or as the manager with a vacancy against which a potential redeployee could be considered.

The manager with the provisionally or actually redundant member of staff, supported by the Head of Department as appropriate, will be responsible for conducting the redundancy consultation process and seeking to support the member of staff in their redeployment efforts. It is expected that managers normally will commence the redundancy consultation process, both individual and collective, four (4) months in advance of the proposed effective date of potential redundancy unless circumstances provide otherwise as outlined in the Job Seekers' Register section above.

The individual consultation process will involve managers in consideration with the member(s) of staff of:

- Advising the member of staff of the identification of their post as provisionally or actually redundant;
- Discussing with them the potential scope and ways to avoid their dismissal on the grounds of redundancy, which may include consideration of voluntary redeployment, severance or early retirement;
- Discussing with them the potential scope and ways to mitigate the consequences of potential dismissal for them.

In considering the scope for redeployment managers will wish to consider members of staff's views on the types of employment and role(s) which the staff may be interested in redeploying to (eg. part time, job share, reduced hours, or lower salary etc.). Where groups of staff are being consulted it is recommended that this process be undertaken in conjunction with the territorial HR Manager. At all stages of consultation staff may be accompanied by a trade union representative or fellow worker. Assistance should also be provided where possible within departments to enable staff without access to PCs to provide electronic copies of their CV and agreed job description in Word '95.

In considering with staff the measures which may be used to avoid potential or actual redundancies, the range of options may include:

- reduction in non-staffing costs;
- methods of increasing income to the faculty, department, section or budget centre affected;
- reduction and/or termination of the use of external staffing resources e.g. agency staff;
- non-replacement of staff following normal staff turnover;
- restrictions on external recruitment in the staff categories affected or in areas to which staff may be redeployed;
- where relevant, reducing or eliminating paid overtime;
- reduction of hours of work or pay;
- redeployment, relocation and/or retraining of members of staff to, and for, alternative types of work, or places of work within the University; and
- the offer of voluntary early retirement or voluntary severance to staff within the faculty, department, section or budget centre affected, or elsewhere.

  The HR Department will continue to provide the relevant trade unions with the formally required information to initiate redundancy consultation on a monthly basis through reports highlighting the affected staff.

However, managers would also be expected to undertake consultation with the relevant trade union representatives at a local level (either on an individual, departmental or faculty etc. basis) concerning the local impact of the provisional or actual redundancies on both the redundant member(s) of staff and the staff who may be affected by the implications of the redundancy situation (eg. workload implications etc.). Such consultation will be undertaken in a meaningful manner with a view to reaching agreement on ways to avoid, to reduce the numbers of, and to mitigate the consequences of the potential redundancies.

The collective consultation process will involve managers in consideration with the trade unions of the:

- Reasons for the redundancy proposals;
- Number and description of members of staff it is proposed to declare redundant;
- Total number of members of staff of any such description employed in the faculty, department, section or budget centre, directly affected;
- Proposed method of selecting the members of staff who may be identified as redundant eg. the selection criteria;
- Proposed method of carrying out the dismissals in accordance with agreed procedures as appropriate. Normally this would be in accordance with the provisions of the Management of Organisational Change Policy: Avoidance and Mitigation of Redundancy and the Management of Compulsory Redundancy Protocol;
- Period over which the dismissals are to take effect eg. the proposed effective date of redundancy;
- Proposed redundancy terms, including whether provision is to be made for pay in lieu of notice, and the method of calculation of the

- Proposed redundancy terms if other than the use of the statutory redundancy payment provisions.

Before conducting the collective consultation process with the local trade union representatives it would be advantageous to discuss the issues with the relevant territorial HR Manager who will seek to support managers in effectively carrying out this process.

The manager with a vacancy against which a potential redeployee could be considered will be responsible for ensuring all relevant staff on the JSR are considered for redeployment. The manager's role is central to the effectiveness of the redeployment process. It is important that managers do not discount the potential suitability of staff on the JSR who may be pertinent to a vacancy without first considering their CVs and job descriptions against the criteria of the person specification for the vacancy. Managers will be expected to organise redeployment interviews and panels within departmental resources.

Managers are encouraged to enter into consultation with the member of staff and the territorial HR Manager regarding offers of redeployment and associated trial periods with an open and flexible approach to optimise the opportunities available. This is particularly encouraged when considering the termination of a trial period.

Under the provisions of the Recruitment & Selection Procedures in departments where there is local administration of the recruitment process, such managers will require to ensure before advertising or appointing as appropriate that they can demonstrate that there were no staff on the JSR who merited an interview or appointment using the JSR Shortleet Assessment Form. Copies of these forms should be provided to the territorial HR Manager as appropriate.

Role of Potential Redeployees

Members of staff have a responsibility to actively contribute to the redundancy consultation process and to seek suitable alternative employment within the University through the redeployment process. Without this the scope to effectively consider opportunities to avoid redundancies or redeploy staff will be significantly constrained.

Staff will be expected to provide their CV information in the standard summary format in Word '95 and to sign a declaration to agree to the release of such personal data for access by relevant managerial staff eg. HR Managers and managers with vacancies (such as Heads of Section/Department, Deans, Principal Investigators) for the purposes of assessment of suitability for redeployment. They will also be expected to provide a copy of their current agreed job description at the same time.

Upon invitation to attend a redeployment interview staff will be expected to provide a supporting letter of application, in addition to the CV already provided. This is intended to enable staff to market themselves effectively through the opportunity to highlight the reasons they consider themselves a suitable match for the post for which they are to be

interviewed. Staff wishing assistance in developing such a statement should contact their line management and/or territorial HR Manager.

Additionally, research staff may wish to seek career guidance or support from the Careers Service, utilising the dedicated resources which are currently available to support research staff in the management of their careers. Furthermore, research staff in IBLS and Urban Studies may wish to avail themselves of the services of CVs.ac.uk, a national web-based recruitment resource currently available on a pilot basis for staff in those departments only. It is intended as a tool exclusively for UK research staff to enable researchers to make their CVs available to other UK HEIs; the websites for IBLS and Urban Studies provide further information on how to access this service.

Staff will be provided with written reasons for non-selection for either interview or appointment for a redeployment opportunity. Staff can appeal in writing against such decisions to the Human Resources Department who will coordinate the management of the appeals process.

Staff are encouraged to enter into consultation with the manager concerned and the territorial HR Manager regarding offers of redeployment and associated trial periods with an open and flexible approach to optimise the opportunities available. This is particularly encouraged when considering the termination of a trial period.

Role of HR in Redeployment :-

The Recruitment Assistants will play a central role in supporting the administration of the redeployment process.

The relevant territorial Recruitment Assistant (RA), following liaison with the territorial Human Resources Assistant, will automatically add members of staff who are potentially or actually redundant to the JSR three (3) months in advance of the proposed effective date of potential redundancy unless sufficient funds to continue employment have been internally financially authorised.

The Recruitment Assistant (RA) will also:

- Ensure the JSR is updated on a weekly basis, and will input the relevant data for members of staff from Delphi and add electronic links to members of staff's CV and agreed job description (where available);
- Provide written reasons for members of staff's non-selection for either interview or appointment for a redeployment opportunity to such staff, utilising the information contained in the JSR Shortleet Assessment Form;
- Organise appeals in cases of dispute over (i) the reasons for non-selection for interview or redeployment, or (ii) the suitability of alternative employment, or (iii) whether a trial period was terminated unreasonably.

The Territorial Human Resources Assistant (THRA) will issue consultation letters to Heads of Departments and the members of staff concerned, normally four (4) months in advance of the proposed effective date of potential redundancy. The THRA will normally issue notice of dismissal on the grounds of redundancy one (1) month after the commencement of the consultation process, taking account of the redundancy notice period required by contract and/or statute and whether staff are being expected to serve their notice period in full or part.

The THRA will liaise on a monthly basis with their counterpart RA to update the JSR as new fixed term contract expiry dates or new proposed effective dates of potential redundancy arise.

The Territorial HR Manager will play a central role in supporting staff and managers in the effective operation of the redeployment process. Within this context the HRM will also:

- Support managers in the development of appropriate job descriptions and person specifications for vacancies;
- Provide advice on the relevant durations of the consultation and notice periods;
- Undertake group redundancy consultations in conjunction with line management;
- Ensure the JSR is updated in relation to the impact of any potential redundancies arising from restructuring exercises etc., whether to add new cases or remove successfully redeployed staff from the JSR;
- Provide guidance to staff concerning completion of the CV proforma
- Review the reasons for non-selection for interview and redeployment following an interview;
- Where there is local administration of the recruitment process, monitor the completion of the JSR Shortleet Assessment Form advise managers and staff on the level of retraining which is reasonable in the circumstances, considering such matters as the nature, extent and means for gaining such retraining;
- Advise managers and staff on the appropriateness and duration of any extension to the four-week trial period or its premature cessation prior to the completion of the four-week period;
- Deliberate upon the extent of salary protection to be offered where relevant;
- Review appeal cases with the territorial Vice-Principal;
- Maintain an overview of the scope for redeployment opportunities available to individual members of staff to seek to ensure the University meets its obligations to each potential redeployee.

EMPLOYEE EMPOWERMENT: A CRUCIAL INGREDIENT IN A TOTAL QUALITY MANAGEMENT STRATEGY.

1. Quality starts with People.

A sound total quality management (TQM) implementation process should be concerned with more than just the mechanical aspects of the change. Instead, it should focus on improving the more indirect value characteristics of the organization such as trust, responsibility, participation, harmony and group affiliation. Empowerment, the most important concept in TQM, is many things, since employees must be empowered to make the necessary organizational changes (Stevens, 1993). The concept of empowerment is based upon the belief that employees needs the organization as much as the organization needs them and that leaders understand that employees are the most valuable asset in the firm.

2. Participative management- more than a management buzzword.

Participative management has become a key word in empowerment. Research has shown that there is a positive link between participation and satisfaction, motivation and performance (Holander, Offerman, 1990: 183). "The self-managed work team is a new way of viewing the relationship of the worker-management-organization" (Keighley,1993: 6). Employee involvement teams, which consists of small groups of employees who work on solving specific problems related to quality and productivity represent one way of particpatitve management. Such teams have proved effective in resolving problems related to productivity and quality, as well as improved employee morale and job satisfaction (Bartol, Martin, 1991: 650).

Whatever the definition is, participative management requires responsibility and thrust to employees. It is important that management recognizes the potential of employees to identify and to derive corrective actions to quality problems (Stevens, 1993: 20). However, according to Stevens (1993: 20), if management refuses to act upon team recommendations, "the team members' faith in the quality program will be destroyed."

Furthermore, critics argue that employees may be given the impression that TQM and employee empowerment is just another management buzzword, and that the decision making process is still dominated at the top of the organizational hierarchy (Scully, 1993: 453). In many organizations, this traditional labor division is the principal cause why managers finds it difficult to delegate responsibility. Scully (1993: 455) also argues that to some people empowerment means more delegation in form of indirect control. Moreover, Stevens (1993: 18) stresses that some subordinates may view empowerment as abandonment and that it leads to organizational anarchy.

3. "We are all in it together."(Bluestone, 1992: 34)

"Workers affected by proposed changes must be involved in the decision to change, else they will fight progress" (Magjuka, 1993: 63). In an empowered organization, people should not expect to be told what to do, but they should know what to do. The primary role of management is "to support and stimulate their people, co-operate to overcome

cross functional barriers, and work to eliminate fear within their own team" (Hand, 1994: 25).

However, many supervisors think that empowerment may lead to them loosing authority and ultimately their jobs. Therefore, it is logical that most of the resistance to empowerment comes from the middle management (Keighley, 1993: 7). Keighley argues that this resistance to change can be reduced by setting, measuring and evaluating performance together with the team (1993: 8). Likewise, Hand argues that supervisors and managers should be trained in order to cope with organizational change (1994: 24).

In addition, managers argue that employees are unable to get the whole picture of the organization, and that they are not all qualified to make decisions. Dobbs (1993: 55) argues that work-teams are unable to see the connection between process improvements and the overall strategy and profitability of the firm.

4. Empower from the "bottom up".
The most important concept of empowerment is to delegate responsibility to the lowest levels in the organization. The decision making process should be to a high degree decentralized and individuals or work designed teams should be responsible for a complete part of work processes (Lawler, 1994: 70).

For instance, Saturn, a highly successful American car manufacturer, empowered its employees by turning assembly lines into dedicated process oriented work stations solely managed by the work team. Even the design process involves a high degree of employee participation. In the Saturn case, empowerment became directly linked to responsibility, and employees make suggestions how to improve processes (Bluestone,1992:38). Stevens suggests that "the ultimate success of a quality program is based on its ownership by employees and their empowerment to make changes" (1993: 20). It is crucially important that management value employee suggestions and manage accordingly. Naturally, workers directly involved in a process knows best how to improve it (McMillan, Mahoney. 1994: 177). In an Empowered organization, employees feel responsible beyond their own job, since they feel the responsibility to make the whole organization work better.

Lawler (1994: 71) does to a certain extent oppose the ideas mentioned in this section. He argues that employee empowerment does not directly constitute to the success of a TQM program since quality is always on the center stage in such a strategy. Opposite to this, employee empowerment is usually the result of an organization's strategy and technology, focusing not only on how to improve cost, speed, and efficiency through quality improvements (Lawler, 1994: 71).

5. Employees- The most important asset in organizations.
Empowered personnel have "responsibility, a sense of ownership, satisfaction in accomplishments, power over what and how things are done, recognition for their ideas, and the knowledge that they are important to the organization" (Turney 1993: 30). Without productive employees, the organization is nothing and can do nothing.

Empowerment works the best when employees need their organization as much as the organization needs them, "and the need is much more than a paycheck and benefit package" (Johnson, 1993: 47).

Johnson (1993: 47) is aware that there is a belief that employees only work to get monetarily compensated. However he argues that it is only true when employees are not able to play an integral part of the organization. Likewise, Mahoney, McMillan (1994) propose that the empowerment process is only successful when there is room for feedback and autonomy in the organizational culture. Only in such a scenario, it is possible to fully utilize the capabilities of your employees. The golden rule is that "leaders have to treat their employees the way they want the bosses to treat them" (Johnson, 1993: 47).

6. Treat Your employees the way you want your customers to be treated.

The most crucial critical success factor in TQM is to recognize the importance of living up to customers expectations (Johnson, 1993: 47). It is important to understand that there is a positive correlation between satisfying internal customers and meeting external customers needs. "Employees who are not treated correctly cannot be expected to treat external customers differently" (Johnson, 1993: 47). Internal satisfaction can be achieved in the following ways: establish a high degree of participative management, decentralization of hierarchy power structures, create a large degree of autonomy throughout the organization and finally the development of effective work groups. All these ways are based on the concept of employee empowerment.

7. Conclusion.

Employee empowerment is more than a management buzzword and a text-book definition. It is a new way of managing organizations towards a more complex and competitive future. A TQM strategy is deemed to fail if empowerment of employees is absent. Quality starts with engaging the people responsible for processes- the people who know the processes the best. The people whom critics argue are unable to understand the holistic aspects of the organization. However, partcipative management has proven very successful in fostering

Types of Probability Distribution

With The Help Of theoretical probability distribution we may list the probabilities for different values of a random variable without performing an experiment. For Instance In an experiment of tossing a coin, we may assign the probabilities for different values of head,random variable,with the help of theoretical probability distribution.Now We Shall Discuss Three Types Of theoretical probability distributions namely (i) Binomial (ii) Poisson, and (iii) Normal Distribution.

BINOMIAL DISTRIBUTION

Binomial distribution is the probability distribution expressing the probability of one set of dichotomous alternatives, i.e. success or failure. In other words, it is used to determine the probability of success in experiments on which there are only two mutually exclusive outcomes. Binomial distribution is discrete probability distribution.

This distribution is applicable to situations with the following characteristics:

1. An experiment consists of a finite number of repeated trials.
2. Each trial has only two possible, mutually exclusive, outcomes which are termed as a 'success' or a 'failure'.
3. The probability of a success, denoted by ***p***, is known and remains constant from trial to trial. The probability of a failure, denoted by q, is equal to ***1 - p.***
4. Different trials are independent, i.e., the outcome of any trial or sequence of trials has no effect on the outcome of the subsequent trials.

Now, $P(r) = {}^{n}C_r p^r q^{n-r}$ is termed as the probability function or probability mass function (p.m.f.) of the distribution.

- ***n*** be the total number of repeated trials,
- ***p*** be the probability of a success in a trial and
- ***q*** be the probability of its failure so that ***q = 1 - p***
- ***r*** be a random variable which denotes the number of successes in ***n*** trials
- ***(n – r)*** trials are failures in ***n*** trials
- ***P(r) =*** Probability of ***r*** successes out of ***n*** trials

Features of Binomial Distribution

1. It is a discrete probability distribution.
2. The mean of Binomial distribution is ***np*** & it increases as 'n' increases with 'p' remaining constant.
3. The Standard deviation of Binomial distribution is $\sqrt{npq}$
4. If ***'n'*** is large and if neither ***'p'*** nor ***'q'*** is too close to zero, Binomial distribution may be approximated to Normal Distribution.
5. If two independent random variables follow Binomial distribution, their sum also follows Binomial distribution.
6. The mode of the Binomial distribution is equal to the value of ***'r'*** which has the largest probability.

Uses of Binomial Distribution

Binomial distribution is often used in various decision-making situations in business. Acceptance sampling plan, a technique of quality control, is based on this distribution. With the use of a sampling plan, it is possible to accept or reject a lot of items either at the stage of its manufacture or at the stage of its purchase.

Example 1: An unbiased die is tossed three times. Find the probability of obtaining the following -
(a) no six, (b) one six, (c) at least one six,
(d) two sixes and (e) three sixes.

Solution: The three tosses of a die can be taken as three repeated trials which are independent. Let the occurrence of six be termed as a success. Therefore, r will denote the number of six obtained.
Further, n = 3 and p = 1/6

(a) Probability of obtaining no six, i.e.,

$$P(r=0)={}^3C_0p^0q^3=1.\left(\frac{1}{6}\right)^0\left(\frac{5}{6}\right)^3=\frac{125}{216}$$

(b) $$P(r=1)={}^3C_1p^1q^2=3.\left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^2=\frac{25}{72}$$

(c) Probability of getting at least one six = 1 - P(r = 0) $$=1-\frac{125}{216}=\frac{91}{216}$$

(d) $$P(r=2)={}^3C_2p^2q^1=3.\left(\frac{1}{6}\right)^2\left(\frac{5}{6}\right)=\frac{5}{72}$$

(e) $$P(r=3)={}^3C_3p^3q^0=3.\left(\frac{1}{6}\right)^3=\frac{1}{216}$$

Example 2: Assuming that it is true that 2 in 10 industrial accidents are due to fatigue, find the probability that: (a) Exactly 2 of 8 industrial accidents will be due to fatigue.
(b) At least 2 of the 8 industrial accidents will be due to fatigue.

Solution: Eight industrial accidents can be regarded as Bernoulli trials each with probability of success *p = 2/10 = 1/5*; the random variable r denotes the number of accidents due to fatigue.

(a) $$P(r=2)={}^8C_2\left(\frac{1}{5}\right)^2\left(\frac{4}{5}\right)^6=0.294$$

(b) We have to find P(r ≥ 2). We can write
P(r ≥ 2) = 1 - P(0) - P(1), thus, we first find P(0) and P(1).

We have $$P(0)={}^8C_0\left(\frac{1}{5}\right)^0\left(\frac{4}{5}\right)^8=0.168$$

and $$P(1)={}^8C_1\left(\frac{1}{5}\right)^1\left(\frac{4}{5}\right)^7=0.336$$

$$\therefore P(r\geq 2)=1-0.168-0.336=0.496$$

Example 3: Suppose it is known that 10% of the students in class wear glasses. If 8 students are selected at random what is probability that

(i) two students wear glasses.

(ii) none of those selected wear glasses

(iii) all those selected wear glasses.

Solution : Here, the probability of a student wearing glasses would be 0.10. Now, q = 0.90 and n = 8. The desired probabilities will be calculated as follows :

(i) Probability that 2 students wear glasses

$P(x = 2) = 8_{C_2} (.90)^6 (.10)^2 = .0744$

(ii) Probability that none of those selected wear glasses.

$P(x = 0) = 8_{C_0} (.90)^8 (.10)^0 = 0.430$

(iii) Probability that all those selected wear glasses.

$P(x = 8) = 8_{C_8} (.90)^0 (.10)^8 = .00000001$

Example 4: (a) The mean and variance of a discrete random variable X are 6 and 2 respectively. Assuming X to be a binomial variate, find P ($5 \leq X \leq 7$).

(b) In a binomial distribution consisting of 5 independent trials, the probability of 1 and 2 successes are 0.4096 and 0.2048 respectively. Calculate the mean, variance of the distribution.

Solution: (a) It is given that np = 6 and npq = 2

q = npq/np = 1/3;

p = 1 – (1/3) = 2/3;

Hence n = 6 x (3/2) = 9

Now $P(5 \leq X \leq 7) = P(X = 5) + P(X = 6) + P(X = 7)$

$$= {}^9C_5\left(\frac{2}{3}\right)^5\left(\frac{1}{3}\right)^4 + {}^9C_6\left(\frac{2}{3}\right)^6\left(\frac{1}{3}\right)^3 + {}^9C_7\left(\frac{2}{3}\right)^7\left(\frac{1}{3}\right)^2$$

$$= \frac{2^5}{3^9}\left[{}^9C_5 + {}^9C_6 \times 2 + {}^9C_7 \times 4\right] = \frac{2^5}{3^9} \times 438$$

(b) Let p be the probability of a success. It is given that

$${}^5C_1 p(1-p)^4 = 0.4096 \text{ and } {}^5C_2 p^2(1-p)^3 = 0.2048$$

Using these conditions, we can write

$$\frac{5p(1-p)^4}{10p^2(1-p)^3} = \frac{0.4096}{0.2048} = 2 \text{ or } \frac{(1-p)}{p} = 4. \text{ This gives } p = \frac{1}{5}$$

Thus, mean is $np = 5 \times \frac{1}{5} = 1$ and $npq = 1 \times \frac{4}{5} = 0.8$

Since (n +1)p, i.e., $6 \times \frac{1}{5}$ is not an integer, mode is its integral part, i.e., = 1.

Example 5: Ten percent of items produced on a machine are usually found to be defective. What is the probability that in a random sample of 12 items

(i) none, (ii) one, (iii) two,

(iv) at the most two, (v) at least two items are found to be defective?

Solution: Let the event that an item is found to be defective be termed as a success.

Thus, we are given n = 12 and p = 0.1

(i) $P(r=0) = {}^{12}C_0 (0.1)^0 (0.9)^{12} = 0.2824$

(ii) $P(r=1) = {}^{12}C_1 (0.1)^1 (0.9)^{11} = 0.3766$

(iii) $P(r=2) = {}^{12}C_2 (0.1)^2 (0.9)^{10} = 0.2301$

(iv) $P(r \le 2)$ = P(r = 0) + P(r = 1) +P(r = 2)

= 0.2824 + 0.3766 + 0.2301 = 0.8891

(v) P(r ≥ 2) = 1 – P(0) – P(1) = 1 – 0.2824 – 0.3766 = 0.3410

Normal Approximation of the Binomial distribution

If n is large and if neither of p or q is too close to zero, the Binomial distribution can be closely approximated by a Normal distribution with standardized variable

$$Z = \frac{X - np}{\sqrt{npq}}$$

Example: Assuming the probability of male birth as ½, find the probability distribution of number of boys out of 5 births. (a) Find the probability that a family of 5 children have (i) at least one boy (ii) at most 3 boys (b) Out of 960 families with 5 children each find the expected number of families with (i) and (ii) above

Solution: Let the random variable X measure the number of boys out of 5 births. Clearly X is a binomial random variable. So we apply the Binomial probability function to calculate the required probabilities.

$P(X = x) = {}^{n}C_x \, p^x \, q^{n-x}$ *for* $x = 0, 1, 2, 3, 4, 5$

The probability distribution of X is given below

$X = x$	:	0	1	2	3	4	5
$P(X = x)$	:	1/32	5/32	10/32	10/32	5/32	1/32

(a) The required probabilities are

(i) $P(X > 1) = 1 - P(X = 0)$

$= 1 - 1/32$

$= 31/32$

(ii) $P(X \le 3) = P(X = 0) + P(X = 1) + P(X = 2) + P(X = 3)$

$= 1/32 + 5/32 + 10/32 + 10/32$

$= 26/32$

(b) Out of 960 families with 5 children, the expected number of families with

(i) at least one boy = $960 * P(X \ge 1)$

$= 960 * 31/32$

$= 930$

(ii) at most 3 boys $= 960 * P(X < 3)$

$= 960 * 26/32$

$= 720$