Manpower Planning

A Report submitted to the
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in
Optimisation Term Project

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Executive Summary

This is an optimization case study about Manpower planning and reducing costs. We are trying to achieve a perfect balance between “Being Humane” and “cutting costs”.

So, in our approach to achieve the above we have formulated equations to find out the minimum costs and the minimum redundancy required. Then, we have tried to come up with that magical number where we are able to achieve both the objectives to our best.

The minimum redundancy according to our assumptions and formulations came out to be 2235, while the minimum cost came out to be 2587.
Redundancy of 2729 and Cost of 5505 should be kept to balance both the concerns.

We have tried to come up with different kinds of sensitivity analysis to see how the value of cost and redundancy changes with respect to the other variables.

For solving our equations and plotting different graphs we have used GAMS and MS Excel.

Problem Description:

This is a common human resource problem where our objective is to find an optimum solution where no of firings and cost of this manpower planning are compromised at a single point. We can go to extremes, by just calculating the minimum costs and please the management, or by just calculating the minimum no of firings and please the labour union. But our objective is to draw a fair, economical and a midway between these two approaches which leads to a compromise between both parties, i.e., labour union and management.

Our approach would be to find these extremes and then find the midpoint of them in order to find a fair solution.

Optimization Model:

Variables: In order to construct the manpower planning conditions, we need to identify the following list of variables.

Strength of Worker Force:

Skilled_workers(i) – Skilled workers at ith Year.

Semiskilled_workers(i) – Semi Skilled workers at ith Year.

Unskilled_workers(i) - Unskilled workers at ith Year.

Recruitment:

Recruited_Skilled_workers(i) – Recruited Skilled workers at ith Year.

Recruited_Semiskilled_workers(i) - Recruited Semi Skilled workers at ith Year.

Recruited_Unskilled_workers (i)- Recruited Unskilled workers at ith Year.

Retrained:

Retrained_Semiskilled_workers (i)- Retrained from semiskilled to skilled at ith year.

Retrained_Unskilled_workers (i)- Retrained from unskilled to semiskilled at ith year.

Downgrading:

Dg_Semiskilled_from_Skilled(i)- Downgraded to semiskilled from skilled at ith year.

Dg_Unskilled_from_Skilled (i)- Downgraded to unskilled from skilled at ith year

Dg_Unskilled_from_Semiskilled (i)- Downgraded to unskilled from semiskilled at ith year

Redundancy:

Redundant_Skilled (i) – Redundant skilled workers at ith year.

Redundant_Semiskilled (i)- Redundant semiskilled workers at ith year.

Redundant_Unskilled (i)- Redundant unskilled workers at ith year.

Overmanning:

Overmanned_Skilled (i)- Overmanned skilled workers at ith year.

Overmanned_Semiskilled (i)- Overmanned semiskilled workers at ith year.

Overmanned_Unskilled (i)- Overmanned unskilled workers at ith year.

Short-term Hiring:

Short_term_Skilled (i)- Short term skilled workers hired at ith year.

Short_term_Semiskilled (i)- Short term semiskilled workers at ith year.

Short_term_Unskilled (i)- Short term unskilled workers at ith year.

Overall Requirement:

Required_Skilled_workers(i)- Requirement of Skilled workers at ith year.

Required_Semiskilled_workers(i)- Requirement of Semiskilled workers at ith year.

Required_Unskilled_workers(i)- Requirement of Unskilled workers at ith year.

Constraints/Equations:

1)Balanced Constraint for Skilled Workers:
Skilled(i).. Skilled_workers(i) =E= 0.95*Skilled_workers(i-1) + 0.9*Recruited_Skilled_workers(i)+ 0.95*Recruited_Semiskilled_workers(i)- Dg_Semiskilled_from_Skilled(i)-Dg_Unskilled_from_Skilled(i)-Redundant_Skilled(i);

2)Requirement Constraint for Skilled workers:
requiredskilled(i).. Skilled_workers(i) - Overmanned_Skilled(i) +0.5*Short_term_Skilled(i) =E=Required_Skilled(i);

3) Balanced Constraint for Semi Skilled Workers
semiskllied(i).. Semiskilled_workers(i) =E= 0.95*Semiskilled_workers(i-1) + 0.80*Recruited_Semiskilled_workers(i)+ 0.95*Retrained_Unskilled_workers(i) - Dg_Unskilled_from_Semiskilled(i) + 0.5*Dg_Semiskilled_from_Skilled(i) - Redundant_Semiskilled(i);

4) Requirement Constraint for Skilled workers:
requiredsemiskilled(i).. Semiskilled_workers(i) - Overmanned_Semiskilled(i) +0.5*Short_term_Semiskilled(i) =E=Required_Semiskilled(i);

5) Balanced Constraint for Unskilled Workers

unskilled(i).. Unskilled_workers(i) =E= 0.9*Unskilled_workers(i-1) + 0.75*Recruited_Unskilled_workers(i) + 0.5*Dg_Unskilled_from_Skilled(i) + 0.5*Dg_Unskilled_from_Semiskilled(i) - Redundant_Unskilled(i);

6) Requirement Constraint for Unskilled workers:

requiredunskilled(i)..Unskilled_workers(i) - Overmanned_Unskilled(i) +0.5*Short_term_Unskilled(i) =E=Required_Unskilled(i) ;

7) Recruitment Constraint for Skilled workers:

recruitementskilled(i).. Recruited_Skilled_workers(i) =L= 500;

8) Recruitment Constraint for Semiskilled workers:

recruitementsemiskilled(i).. Recruited_Semiskilled_workers(i) =L= 800;

9) Recruitment Constraint for Unskilled workers:

recruitementunskilled(i).. Recruited_Unskilled_workers(i) =L= 500;

10) Retraining Constraint for Unskilled workers:

retrainedfromunskilled(i).. Retrained_Unskilled_workers(i) =L= 200;

11) Retraining Constraint for Unskilled workers:

retrainedfromsemiskilled(i).. Retrained_Semiskilled_workers(i) =L= 0.25*Skilled_workers(i);

12) Overmanning Constraint :

overmanned(i).. Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =L= 150;

13) Short Term Constraint for Skilled workers:

shortermunskilled(i).. Short_term_Unskilled(i) =L=50;

14) Short Term Constraint for Skilled workers:

shortermsemiskilled(i).. Short_term_Semiskilled(i) =L= 50;

15) Short Term Constraint for Skilled workers:

shortermskilled(i).. Short_term_Skilled(i) =L=50;

Q1.

In order to reduce the number of firings we have to minimize the number of total redundant workers under the given circumstances. Hence the objective function will be

Objective Function:

Z =E= sum(i, Redundant_Skilled(i) + Redundant_Semiskilled(i) + Redundant_Unskilled(i)) ;

Results:

Z =   2235

For year 0,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	975	500		0	0	50	0
SemiSkilled	830	800	552	0	0	50	-645
Unskilled	375	500	200	0	0	50	-1600

For year 1,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	1000	500		525	0	0	0
SemiSkilled	1428	800	156	0	0	0	28
Unskilled	975	500	3	0	0	50	0

For year 2,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	1500	500		0	0	0	0
SemiSkilled	2000	800	105	0	0	0	0
Unskilled	500	0	0	0	377	0	0

For Year 3,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	2000	500		0	0	0	0
SemiSkilled	2500	750	131	0	0	0	0
Unskilled	150	0	0	0	300	0	150

Q2.

In order to minimize the manpower costs we have to minimize the cost beared in the following situations according to the skill possessed by every worker

- Overmanning

- Redundancy
- Short-Term Hiring
- Retraining

Hence the objective function will be

Objective Function:

Z =E= sum(i,400*Retrained_Semiskilled_workers(i) + 500*Retrained_Untrained_workers(i) + 200* Redundant_Unskilled(i) + 500* (Redundant_Skilled(i) + Redundant_Semiskilled(i)) + 500* Overmanned_Skilled(i) + 800* Overmanned_Semiskilled(i) + 500* Overmanned_Unskilled(i) + 500* Short_term_Unskilled(i) + 400*Short_term_Semiskilled(i) + 400* Short_term_Skilled(i)) ;

Results:

Z = 2587

For year 0,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	975	500		0	0	50	0
SemiSkilled	1475	800	552	0	0	50	-645
Unskilled	375	500	878	0	0	50	-1600

For year 1,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	1105	500		334	0	0	0
SemiSkilled	1400	0	66	191	0	0	28
Unskilled	975	500	200	0	0	50	0

For year 2,

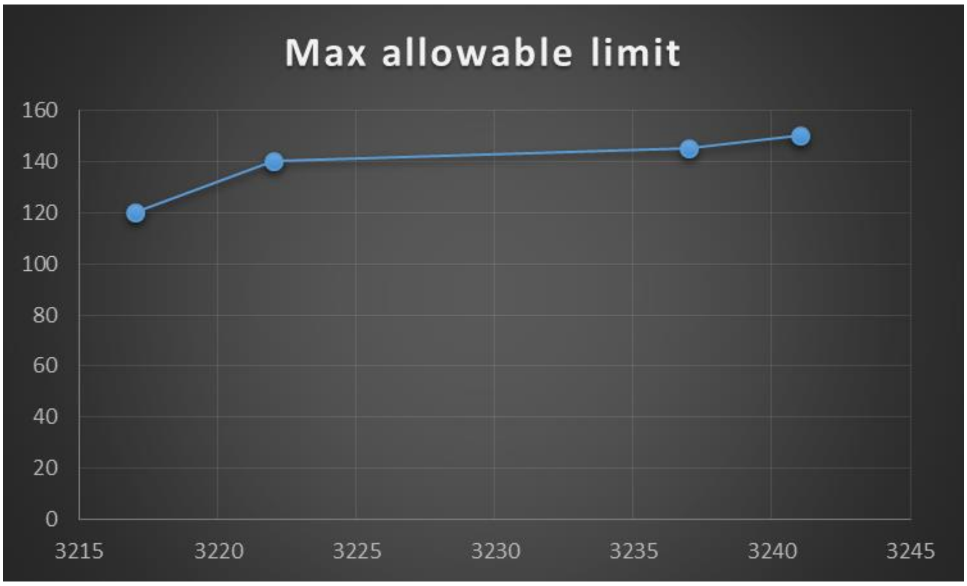
Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	1500	500		0	0	0	0
SemiSkilled	2000	800	0	0	0	0	0
Unskilled	500	0	31	0	377	0	0

For Year 3,

Workers	Total	Recruitment	Retrained	Downgardes	Redundant	Shortterm	Overmanned
Skilled	2000	500		0	0	0	0
SemiSkilled	2500	750	131	0	0	0	0
Unskilled	150	0	0	0	300	0	150

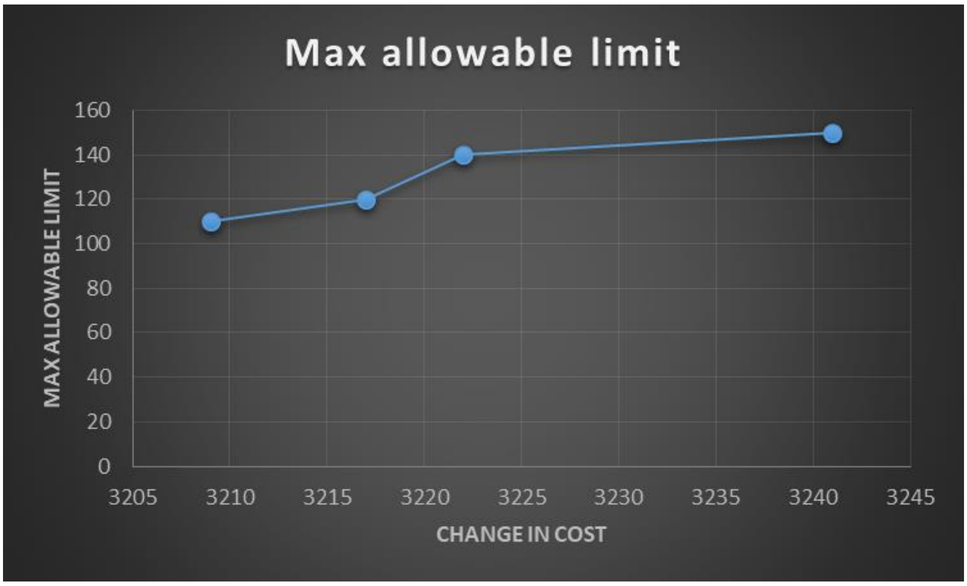
Q3.

<u>Number of firings changes as a function of the maximum allowable number</u>



For this question, we added the constraints for maximum allowable limits and observed how the number of firing varies with it. The constraints added in different iterations are:
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 150;
No of firings: 3241
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 145;
No of firings: 3237
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 140;
No of firings: 3222
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 120;
No of firings: 3217
As we can see in the above, as our allowable maximum limit is proportional to the redundancy. As the value of maximum allowable limit increases so does the redundancy.

<u>Cost changes as a function of the maximum allowable number</u>



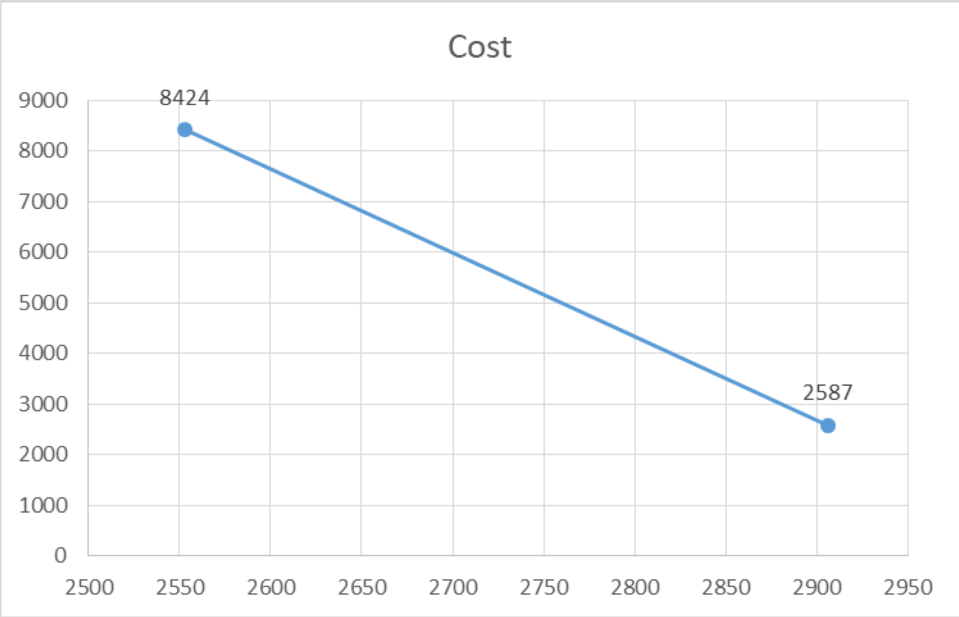
For this question, we added the constraints for maximum allowable limits and observed how the cost varies with it. The constraints added in different iterations are:
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 150;
No of firings: 3241
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 140;
No of firings: 3222
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 120;
No of firings: 3217
Overmanned_Skilled(i) + Overmanned_Semiskilled(i) + Overmanned_Unskilled(i) =E= 110;
No of firings: 3209

As we can see in the above, as our allowable maximum limit is proportional to the cost. As the value of maximum allowable limit increases so does the cost.

Q4.

The approach for this question is that we have found the minimum redundancy and the associated cost with it.

After this, we calculated the minimum cost and the associated redundancy with it.
We found the midpoint of the line that we see below and that would be our optimal solution.



From the graph above, we can see that redundancy of 2729 and cost of 5505 should be kept as that balances both the concerns.

Q5.

The **assumptions** that we have taken are as follows:

1. We are assuming that all the problems will be solved by using linear programming.

2. In the retraining equations we have assumed that the semi-skilled workers can be trained to become skilled and unskilled can be trained.

3. We have ignored the decimals in our GAMS output and converted them to whole number since the variables represent humans.

4. We have assumed that once a worker is degraded they leave and hence do not require retraining.

5. All the equations are made on yearly basis and not on monthly/daily basis.

6. We have considered the costs given in the question although the expenses might be caused by other things like salaries etc. in real life.

Q6.

For T>3 years we will set the required sets for skilled and semiskilled workers to be dynamic for every i>=4

We will be setting the values as

Required_Skilled (i)=Required_Skilled (i-1)*1.02;

Required_Semiskilled (i)=Required_Semiskilled (i-1)*1.02;

For achieving above objective we can set the parameter value uptil 3 and then by using loop in GAMS we can manipulate for 4 and above by checking a condition on i that i>=4.

Results for i=6:

No of Redundant workers: 2533

Cost beared by the company : $3121.162

GAMS Modellling:

- In our GAMS model we have used 24 variables(including z) and 15 constraints.
- We have used Cplex and solved the problem using LP.

Conclusion:

With the help of the above modelling we have successfully been able to find optimal values for cost and redundancy and hence, achieve our objective.

Appendix:

Please see the attached GAMS files and the Excel sheets in the folder "Optimization files."