Optimizing Manpower Planning: A Goal Programming Approach

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This paper examines a longitudinal model of a manpower planning system. The demand for effective manpower is determined by the state of a finite Markov chain. There are delays in training effective manpower, and effective manpower is an input to the training process. Thus, it is not always available to meet demand. This paper presents an operational method for calculating optimal accession policies. This calculation can in turn be used to find the equilibrium operating rules for the system. The model is a useful device for measuring the impact of alternate assumptions about continuation rates, manpower utilization policies, demand levels, and transition probabilities in the demand process.

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Objective of the Study

To develop a manpower planning policy, vide Goal Programming approach for manpower projection and distribution of executives at entry, middle and senior manager levels in the organization. Accordingly, a Goal Programming Model will be developed by taking an illustration from a business unit of a manufacturing organization 'M' having three job classifications.

Literature Review

Goal Programming is a goal-oriented optimization technique which is aimed to solve problems having multiplicity of objectives in a decision- making skyline/perspective. It's a multiple criteria decision making (MCDM) technique. Wikipedia definition suggests that Goal Programming can be thought of as an extension/generalization of linear programming to handle multiple objective measures. Each of these measures is given a goal/target value to be attained. The unwanted deviations from this set of target values are then minimized in an achievement function. As satisfaction of the target is deemed to satisfy the decision maker(s), an underlying satisfying philosophy is assumed. Goal Programming is used for following analysis: (a) Determine the required resources to achieve a desired set of objectives; (b) Determine the degree of attainment of the goals with the available resources; (c) Providing the best satisfying solution under a varying amount of resources and priorities of the goals.

Goal Programming, was conceived by Charnes and Cooper (1961). Later on Ijiri (1965), Jaaskelanen (1969), Lee and Clayton (1970), Ignizio (1976), Gass (1986), Romero (1991), Tamiz and Jones (1996) extended and enhanced the tool. Since then researchers like Schniederjans and Hoffman (1992) have worked on the extensions of Goal Programming methodology such as preemptive/lexicographic Linear Goal Programming, Integer Goal Programming, Zero-one Goal Programming; Romero (2001) on extended Lexicographic Goal Programming; Lee (1972) on extensive surveys of fields and its applications; Schniederjans (1995), Tamiz et al. (1998) worked on production planning, financial planning, capital budgeting planning etc.

Baran et al (2013) formulated a Goal Programming model by using genetic algorithm to solve economic environmental electric power generation problem with interval valued target goals. Dean and Schniederjans (1990) applied a Goal Programming approach to production planning for flexible manufacturing systems. Ghosh et al (2005) formulated a Goal Programming in nutrient management for rice production in West Bengal.

Golany et al (1991) proposed a Goal Programming inventory control model which was being applied in a large chemical plant. The proposed model came out with an efficient solution which impacted the overall levels of decision -making satisfaction with the multiple fuzzy goal values.

Larbani and Aouni (2011) suggested a new approach for generating efficient solutions within the Goal Programming Model followed by the efficient test for the Goal Programming solution. Leung and Ng (2007) suggested a Goal Programming Model for production planning of perishable products. Mukherjee and Bera (1995) discussed the solution of a project selection by applying Goal Programming technique. Sen and Nandi (2012a) applied a Goal Programming approach to rubber plantation planning in Tripura. Sen and Nandi (2012b) formulated an optimal model by using Goal Programming for a rubber wood door manufacturing factory in Tripura. Sen and Nandi (2012c) reviewed the Goal Programming and its application in plantation management.

Sinha and Sen (2011) formulated a strategic planning by using the Goal Programming approach to maximize production quantity of tea, profit and demand and minimize expenditure and processing time in different machines installed in tea industry of Barak Valley of Assam in order to flourish the tea industries.

Tamiz et al (1996) formulated an exploration of linear and Goal Programming Models in the downstream oil industry.

Leung and Chan (2009) developed a pre-emptive Goal Programming model for aggregate production planning problem with different operational constraints. Sharma (1995) studied lexicographic Goal Programming to solve a product mix problem in a large steel manufacturing unit.

Ghiani et al (2003) proposed a mixed integer linear Goal Programming Model for allocation of production batches to subcontractors through fuzzy set theory in an Italian textile company which resulted to outperform the hand-made solutions put to use by the management so far. Lee et al (1989) formulated industrial development policies by a zero-one Goal Programming approach.

Nja and Udofia (2009) formulated the mixed integer Goal Programming Model for flour producing companies. Pati et al. (2008) formulated mixed integer Goal Programming Model to assist in proper management of the paper recycling logistics system. Belmokaddem et al (2009) proposed a model to minimize total production and work force costs, carrying inventory costs and rates of changes in work force using fuzzy Goal Programming approach with different importance and priorities to aggregate production planning.

Fazlollahtabar et al (2013) formulated a fuzzy Goal Programming for optimizing service industry market using virtual intelligent agent. Mekidiche et al (2013) applied weighted additive fuzzy Goal Programming approach to aggregate production planning. Petrovic and Akoz (2008) proposed a fuzzy Goal Programming Model for solving the problem of loading and scheduling of a batch processing machine. Yimmee and Phruksaphanrat (2011) proposed a fuzzy Goal Programming Model for aggregate production and logistics planning to increase profit and reduce change of workforce level.

Case Study

In a business unit of a manufacturing organization 'M', there are three managerial levels – Entry level (X1), Middle level (X2) and Senior Level (X3). The various levels like U1 & U2, U3 & U4, U5 & U6 are categorized in X3, X2 and X1 respectively. The present distribution of executives in various levels are as in Table 1.

Table 1 Distribution of Executives in Various Levels

Job Classification	Distribution of Executives		
	Category	Level	Nos.
Senior Level	X3	U1	2
		U2	18
Middle Level	X2	U3	20
		U4	60
Entry Level	X1	U5	100
		U6	140

The manning policy of the organization is that executives either move from one job impact level to next higher level or stay at the same impact level, or leave the business unit/organization due to superannuation/ resignation.

Present Promotion Policy

Case (a) Movement from X1 to X2 (Table 2)

Trend analysis for last three financial years shows that 60 % of X1s remained as X1s, 30% got promoted to X2, and 10% left the organization (S: Separation). Similarly, with respect to X2s, 5% got demoted to X1, 70% remained as X2s, and 25% left the organization. For the purpose of the study, the recent manning policy of the business unit will be treated as "target manpower planning policy."

Table 2 Present Promotion Policy: Case (a) Movement of Managers from category X1 to X2

Category	Movement Next Year		
	X1	X2	S
X1	0.60	0.30	0.10
X2	0.05	0.70	0.25

Case (b) Movement from X2 to X3 (Table 3)

Table 3 Present Promotion Policy: Case (b) Movement of Managers from category X2 to X3

Category	Movement Next Year		
	X2	X3	S
X2	0.70	0.10	0.20
X3	0.05	0.75	0.20

Trend analysis for last three financial years shows that 70 % of X2s remained as X2s, 10% got promoted to X3, and 20% left the organization (S). Similarly, with respect to X3s, 5% got demoted to X2, 75% remained as X3s, and 20% left the organization.

Model Summary

For the purpose of the study, job assignments will be considered to impact level in the organization or job classification as detailed:

X1= Entry level executives; X2 = Middle level executives; X3 = Senior level executives;

S = Executives superannuating or leaving the organization.

Task to be modeled: Formulating a manning policy to arrive at the desired distribution of Executives across levels within the organization with respect to current manning.

GP Model Input: Present inventory of executives and the desired future distribution.

GP Model Output: To identify "optimal" promotion policy that will achieve the desired future distribution of executives.

Recruitment of new executives will also be an aspect to offset the gap in desired vs actual manpower requirements.

Model Representation

i) Representation of Human Resource Planning for Case (a) and Case (b) through Markov analysis (Fig. 1)

ii) Representation of Human Resource Planning for Case (a) and Case (b) through Goal Programming Approach (Fig. 2)

Fig. 1 Model Representation of Human Resource Planning through Markov Analysis

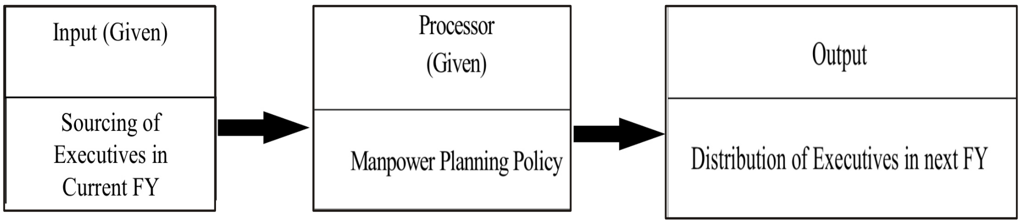
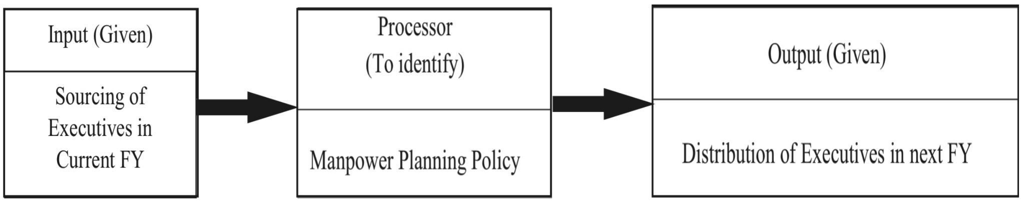


Fig. 2 Model Representation of Human Resource Planning through Goal Programming



Variables Taken into Account

Xi : No. of executives at job impact level 'i'; where i= 1,2,3…

XiXj : No. of executives currently at job impact level 'i' who will be at job impact level 'j' in accordance to manning policy.

X1X1 = No. of X1 executives who remain as it is in category X1.

X1X2 = No. of X1 executives who get promoted to category X2.

X2X1 = No. of X2 executives who get demoted to category X1.

X2X2 = No. of X2 executives who remain as it is in category X2.

X2X3 = No. of X2 executives who get promoted to category X3.

X3X3 = No. of X3 executives who remain as it is in category X3.

X3X2 = No. of X3 executives who get demoted to category X2.

XiS : No. of executives who leave the company from job impact level Xi; where i= 1,2,3…

X1S = No. of X1 executives who resigns/ superannuates.

X2S = No. of X2 executives who resigns/ superannuates.

X3S = No. of X3 executives who resigns/ superannuates.

NXi – No. of executives to be recruited for job impact level Xi; where i= 1,2,3…

NX1 = No. of executives recruited to offset the vacancies in X1.

NX2 = No. of executives recruited to offset the vacancies in X2.

NX3 = No. of executives recruited to offset the vacancies in X3.

Condition for Manpower Projection in Goal Programming Representation

The model will meet the manning projected in accordance with manpower planning policy subject to fulfilling the following conditions:

(a) The sum of total executives required for next year is less than or equal to the sum of total executives currently on the roll of the organization;

(b) Manpower planning policy allows for movements of executives between various job impact levels.

i) Representation of Human Resource Planning for Case (a) through Markov Analysis Case (a) Movement from X1 to X2 (Fig. 3)

Fig. 3 HR Planning for Case (a) through Markov Analysis

X1	X2	S
240	80	0

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	X1	X2	S
X1	0.60	0.30	0.10
X2	0.05	0.70	0.25
S	0	0	1

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X1	X2	S
148	128	44

Table 4 First Year Managerial Transitions in Accordance with Current Manning Policy

Category	Movement next year			
	X1	X2	S	
X1	144	72	24	240
X2	4	56	20	80
Total	148	128	44	320

Table 4 shows the promotion, demotion, staying at same level and superannuation/ resignation of executives in the current financial year if the present manning policy is being used. Accordingly, the distribution of 148 X1s & 128 X2s with respect to present manning policy would be:

No. of X1s who will remain in the same position = 144;

No. of X2s to be demoted as X1 = 4;

No. of X2s who will remain in the same position = 56;

No. of X1s to be promoted as X2s = 72;

No. of X1s leaving the business unit/ organization= 24

No. of X2s leaving the business unit/ organization =20

i) Representation of HRP for Case (a) through Goal Programming Model (Fig. 4)

Present inventory of executives = 240 X1s and 80 X2s.

Projected/forecasted manning = 150 X1s and 130 X2s in the next financial year.

Fig. 4 HR Planning for Case (a) through

Given

X1	X2	S
240	80	0

Output

	X1	X2	S
X1	?	?	?
X2	?	?	?
S	0	0	1

= Given

X1	X2	S
150	130	40

Goal/Manpower Projection

The projection for X1s and X2s are shown in Table 5.

Table 5 Next Year Requirements/ Goals

Category	Present manning	Movement in current FY	Goal * (Next FY)
X1	240		150*
		X1X1	144
		X2X1	4
X2	80		130*
		X1X2	72
		X2X2	56
S	-		40*
		X1S	24
		X2S	20

* stands for – Goal for next FY

Inference from Table 5

- Manning in accordance with the policy would be 148 X1s: 144 X1X1s + 4 X2X1s.
- To meet the sourcing target of 150, X1X1 + X2X1 must be 150
- Identification of a policy to source 150 X1s approximately close to the current manning policy or manning for X1X1 = 144 and X2X1= 4 apx.

Supply Equality Constraints

X1 Supply: X1X1 + X1X2 + X1S = 240 ---------------------------------------(i)

X2 Supply: X2X1 + X2X2 + X2S = 80 --------------------------------------(ii)

Possible movement (i.e. will remain in the same position/promotion/superannuation/resignation) of current 240 X1s and 80 X2s is depicted by Constraints (i) and (ii).

Requirement Equality Constraints

X1 Requirement: X1X1 + X2X1 + NX1 = 150-------------------------------(iii)

X2 Requirement: X1X2 + X2X2 + NX2 = 130-------------------------------(iv)

Projected/ forecasted manning is depicted by Constraints (iii) and (iv).

Goal Constraints and Deviation Variables

X1X1 Goal: X1X1 – d1+ + d1- = 144 (v)

X1X2 Goal: X1X2 – d2+ + d2- = 72 (vi)

X1S Goal: X1S – d3+ + d3- = 24----(vii)

X2X1 Goal: X2X1 – d4+ + d4- = 4--(viii)

X2X2 Goal: X2X2 – d5+ + d5- = 56 (ix)

X2S Goal: X2S – d6+ + d6- = 20-----(x)

NX1 Goal: NX1 – d7+ + d7- = 0*---(xi)

NX2 Goal: NX2 – d8+ + d8- = 0*---(xii)

Each goal has variation allowance (+/ -) from the actual/projected goal. For instance, in equation (v) of X1X1 goal, the deviation variables allow for surplus/ deficit (d1+/ d1-) for 144 goal.

To reflect the relative importance of meeting the projected goal, priorities & weights are assigned to the deviation variables. Lower priority numbers is more important than higher priority numbers. GP will consider priority 1 goals first rather than priority 2 goals.

Manning Projection/Distribution through Goal Programming

Table 6 displays the first run goal programming input & output.

Priorities and weights of all Goal selected = 1

Projected/Forecasted X1 = 150; X2 = 130

New Recruitment = Nil

Table 6 First Run Goal Programming Input & Output

Category	Present manning	Movement in current FY	Goal * (Next FY)	Priority/ Weight	Manning in next FY	Deficit (-) Surplus (+)
X1	240		150*			
		X1X1	144	1/1	146	+2
		X2X1	4	1/1	4	
X2	80		130*			
		X1X2	72	1/1	74	+2
		X2X2	56	1/1	56	
S	-		40*			
		X1S	24	1/1	20	-4
		X2S	20	1/1	20	

*this sign stands for – Goal for next FY

The goals, determined from the current or target promotion policy are to provide 144 X1s from X1 and 4 X1s by demotions from X2. For example, the X1 forecasted requirement for next year is 150, and the policy goals for supplying X1s are X1X1 = 144 and X2X1 = 4. Manning column for next financial year represents the identified manning policy which depicts the sourcing of 146 X1X1s and 4 X2X1s.

Sourcing/Manning of Executives in Next Financial Year

Table 7 depicts feasible GP solution and shows the movement of executives in the organization in next financial year and the manner in which projected requirement of 150 X1s and 130 X2s will be met.

Case (b) Movement from X2 to X3

i) Representation of HRP for Case (b) through Markov analysis

Case (b) Movement from X2 to X3 (Fig. 5)

Table 7 Sourcing/Manning of Executives in Next FY

Position	Movement Next Year			
	X1	X2	S	Total
X1	146	74	20	240
X2	4	56	20	80
	150	130	40	320

Table 8 First Year Managerial Transitions via Current Manning Policy

Category	Movement Next Year			
	X2	X3	S	Total
X2	56	8	16	80
X3	1	15	4	20
	57	23	20	100

Fig. 5 HR Planning for Case (b) through Markov Analysis

X2	X3	S
80	20	0

×

	X2	X3	S
X2	0.70	0.10	0.20
X3	0.05	0.75	0.20
S	0	0	1

=

X2	X3	S
57	23	20

The distribution of 57 X2s and 23 X3s with respcet to present manning policy would be as in Table 8.

No. of X2s who will remain in the same position = 56;

No. of X3s to be demoted as X2 = 1;

No. of X3s who will remain in the same position = 15;

No. of X2s to be promoted as X3s = 8;

No. of X2 leaving the business unit/organization= 16

No. of X3 leaving the business unit/organization = 4

i) Representation of HRP for Case (b) through Goal Programming Model

Present inventory of executives = 80 X2s and 20 X3s.

Projected/forecasted manning = 60 X2s and 30 X3s in the next financial year.

Fig. 6 HR Planning for Case (b) through Goal Programming

Given

X2	X3	S
80	20	0

Output

	X2	X3	S
X2	?	?	?
X3	?	?	?
S	0	0	1

= Given

X2	X3	S
60	30	20

Goal/ Manpower Projection

The projection for X1s and X2s are shown in Table 9.

Table 9 Goal/ Manpower Projection

Category	Present manning	Movement in current FY	Goal* (Next FY)
X2	80		60*
		X2X2	56
		X3X2	1
X3	20		30*
		X2X3	8
		X3X3	15
S	-		10*
		X2S	16
		X3S	4

*stands for - Goal for next FY

Inference from Table 9

- Manning in accordance with the policy would be 57 X2s: 56 X2X2s + 1 X3X2s.
- To meet the sourcing target of 80, X2X2 + X3X2 must be 80.
- Identification of a policy to source 80 X2s approximately close to the current manning policy or manning for X2X2 = 56 and X3X2= 1 apx.

Supply Equality Constraints

X2 Supply: X2X2 + X2X3 + X2S = 80---(a)

X3 Supply: X3X2 + X3X3 + X3S = 20--- (b)

Possible movement (i.e. will remain in the same position/promotion/superannuation/resignation) of current 80 X2s and 20 X3s is depicted by Constraints (a) and (b).

Requirement Equality Constraints

X2 Requirement: X2X2 + X3X2 + NX2 = 60------------------------------(c)

X3 Requirement: X2X3 + X3X3 + NX3 = 30------------------------------(d)

Projected/ forecasted manning is depicted by Constraints (c) and (d).

Goal Constraints & Deviation Variables

X2X2 Goal: X2X2 – d1+ + d1- = 56--(e)

X2X3 Goal: X2X3 – d2+ + d2- = 8---(f)

X2S Goal: X2S – d3+ + d3- = 16 ----(g)

X3X2 Goal: X3X2 – d4+ + d4- = 1----(h)

X3X3 Goal: X3X3 – d5+ + d5- = 15----------------------------------- (i)

X3S Goal: X3S – d6+ + d6- = 4-------(j)

NX2 Goal: NX2 – d7+ + d7- = 0*----(k)

NX3 Goal: NX3 – d8+ + d8- = 0*-----(l)

Manning Projection/Distribution through Goal Programming

Table 10 displays the first run goal programming input and output.

Priorities and weights of all Goal selected = 1

Projected/Forecasted X2 = 60; X3 = 20

New Recruitment = Nil

Table 10 Manning Projection/Distribution through Goal Programming

Category	Present manning	Movement in current FY	Goal* (Next FY)	Priority/ Weight	Manning in next FY	Deficit (-) Surplus (+)
X2	80		60*			
		X2X2	56	1/1	59	+3
		X3X2	1	1/1	1	
X3	20		20*			
		X2X3	8	1/1	5	-3
		X3X3	15	1/1	15	
S	-		20*			
		X2S	16	1/1	16	
		X3S	4	1/1	4	

*this stands for - Goal for next FY

The goals, determined from the current or target promotion policy, are to provide 56 X2s from X2 and 1 X2 by demotions from X3. For example, the X2 forecasted requirement for next year is 60, and the policy goals for supplying X2s are X2X2 = 59 and X3X2 = 1. Manning column for next financial year represents the identified manning policy which depicts the sourcing of 59 X2X2s and 1 X3X2s.

Sourcing/Manning of Executives in Next Financial Year

Table 11 depicts feasible Goal Programming solution and shows the movement of executives in the organization in next financial year and the manner in which projected requirement of 60 X2s and 20 X3s will be met.

Table 11 Sourcing/Manning of Executives in Next FY

Position	Movement next year			
	X2	X3	S	Total
X2	59	5	16	80
X3	1	15	4	20
	60	20	20	100

Conclusion

An attempt was made in one of the business units of the organization 'M1' to use Goal Programming Model approach to identify a suitable manpower planning policy for future distribution of executives in various categories. While as per GP Model feasible solutions were arrived at, however, the surplus/deficit of executives in various categories may be offset by new recruitment; by creating a bench strength wherein the pool of surplus executives arising out of promotion may be absorbed in the concerned category as and when vacancy arises.

While mathematical feasibility appears to have been attained in the study conducted, practical feasibility should be cross checked by HR executives for a realistic scenario in the organization in terms of accurate manpower projection.

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