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Research Paper

Mathematics

Application of Markovian Theory in Manpower planning – A case study

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ABSTRACT

Humans are considered as the most crucial, volatile and potentially unpredictable resource which an organization utilizes. Manpower planning seeks to make the links between strategy, structure and people more explicit. The purpose of manpower planning is to get a better matching between manpower requirement and manpower availability. Manpower planning is particularly suitable for the application of statistical techniques. In this paper an optimization model for manpower system is considered where vacancies are filling up by promotion and recruitment in Automation system engineering private limited. This study proposed a method for the determination of the transition probability of promotion and recruitment vector by using markovian theory with certain assumptions.

KEYWORDS: Manpower planning, Markov Model

Introduction

Any organization owes its success to the important factors viz Manpower and Planning, besides other factors. Manpower is the most important resource and its development hold the key to the health of the organization. A firm cannot hire several hundred engineers and get them on board overnight; nor can it develop management talent in just a few weeks. Manpower planning consists of putting right number of people, right kind of people at the right place, right time doing the right things for which they are suited for achievement of goals of the organization. Manpower planning has got an important place in the arena of industrialization. Manpower planning modeling has been accomplished by different approaches but the Markov Chain approach appears to offer more intuitive appeal than others like optimization method such as simulation, renewal theory, and decision calculus, among others. In this paper we are going to use markov model for determination of transition probability and recruitment vector of manpower planning of Automation system engineering private limited.

Automation system engineering private limited established in the year 1982, as providing SCADA solution to small scale industries and were pioneers in giving SILO management system to Indian industries and dealing in process control instruments. Their participation with instrument vendors and technology trend. They act as a bridge between technology and application, as they are in a position to provide these technologies and products in their customer solutions. They have three strategically located offices having corporate Head Quarter housed in Independent corporate building "automation house" at Ahmedabad and branch office at Mumbai, Delhi and Bangalore. Here we have collected data from Ahmedabad head quarter.

Research Problem

Manpower plays a very important role in any organization. Vacancies in any grade of an organization are filled either with promotion from next lower grade or by new recruitment. In general promotion can be classified under policy namely, promotion based on efficiency and promotion based on seniority. Here, seniority means the length of service an employee acquired in each grade and efficiency means the measure of specialized skills or performance in the jobs which could be rated on a scale amenable to quantitative analysis and ranked in ascending order depending on their performance. The study is designed to help the management of Automation system engineering private limited company. The purpose of study is to identify the percentage of employees to be promote and recruit in Automation system engineering private limited so that the organization has to benefit.

Literature Review

A. Srinivasan, P. Mariappan and S. Dhivya presented stochastic models on time to recruitment in a two grade manpower system using different polices of recruitment. A two grade organization in which depletion of manpower occurs due to its policy decisions is considered. They have constructed two mathematical models in which employing two different univariate recruitment policies, based on shock model approach. But the mean and variance of the time to recruitment are obtained for both the models under different conditions. K. Nilakantan, Jayaram K. Sankaran and B.G. Raghavendra have constructed a model of hierarchical manpower systems – called the proportionality Markov manpower system model, which follow proportionality policies in recruitment and promotion of their staff, ostensibly with a view to safeguard the career interests of their existing employees. They took the study of a class of Markov manpower systems wherein the recruitment to each level or grade of the organization is restricted to a strict proportion of the promotions to it. Such restrictive covenants on the number of new employees recruited from external sources to a grade vis-a` -vis the number of employees promoted to it from within the organization, were often introduced into the promotion and recruitment policies of many organizations, especially in countries wherein the inter-organizational mobility of employees was low or wherein alternative employment opportunities were limited, and was the genesis of these policies. Their model yields a more practicable means of control of the system. It also has the additional advantage that it can be used to achieve a desired blend of existing and fresh external manpower in an organization. Here to achieve manpower requirement of Automation system engineering private limited we are going to consider following Markov model for manpower planning (Raghvendra B.G. 1991)

Mathematical Model

Following Bartholomew and Vadja (Setlhare K.), the Markov model for manpower planning system can be described by the help of following notations:

t = 1,2,...,T : Planning periods, with T being the horizon; usually each value of t represent a year;

i,j = 1,2,...,K : 'states' of the system, representing the various grades of levels of members of staff of the organization;

$N_j(t)$: Number of staff in grade j at beginning of period t;

$P_{ij}(t)$: Probability that a member of staff in grade I at the beginning of period t is in grade j at the beginning of the next time period

$R_j(t)$: Number of new recruits to grade j during period t

$W_j(t)$: Wastage factor representing the proportion of members of staff in grade j, leaving the system during period t due to retirement, death, resignation, etc.

The states of the system are mutually exclusive and exhaustive. If t = 1 represent the current period then $N_j(1)$, for various values of j, represents the existing staff structure. Then, it is well known that under certain Markovian assumptions

$$N_j(t+1)=\sum_{i=1}^{K} P_{ij}(t)N_i(t)+R_j(t) \text{ for all j = 1,2,....K} \quad (1)$$

Since any member of the staff would either stay in the same grade, move to another grade or leave the system, it follows that

$$\sum_{j=1}^{K} P_{ij}(t)+W_i(t)=1 \text{ for all i = 1,2,...K} \quad (2)$$

The limiting behaviour of the system, that is, the structure of the organization after a sufficiently long period of time, can be derived under certain assumptions about $P_{ij}(t)$ (see Vajda,2 for example). Assumptions

1. The system states are mutually exclusive
2. N(1) , the vector of existing staff structure is known and N(t) , the vector of staff requirement for that future period are assumed to be known over a finite period of time T (t = 1, 2, 3, ...T).
3. The expected strength of staff at any grade j at time point t = 1, 2, 3, ...T is known.
4. w(t), the wastage vectors are known, t = 1, 2, 3, ...T.
5. Promotion to a grade from the next lower grade is allowed under both aspects of seniority and efficiency.
6. Promotion from other lower grades to an upper grade is allowed based only on their performance ratings (efficiency levels).

Here we assume that the strength of staff at any grade is the same at various time points over a finite interval (0, T).

That is $N_j(1)=N_j(2)=...=N_j(T): \forall\, j=1,\,2,...,k$ As there are

no double promotion and demotions, promotions only to the next higher grade is allowed, equation (1) and (2) take the form

$$N_j(t+1)=P_{jj}(t)N_j(t)+P_{(j-1)j}(t)N_{j-1}(t)+R_j(t) \quad \text{---- (3)}$$

$$P_{jj(t)}+P_{(j-1)j}(t)+w_j(t)=1; \forall j=1,2,...,k \quad (4)$$

With the above assumptions, the number of staff to be promoted and the number to be recruited for various grades can be estimated as follows. For t = 1 and j = k, equation (3) and (4) become

$$N_k(2)=P_{kk}(1)\,N_k(1)+P_{(k-1)k}(1)N_{k-1}(1)+R_k(1) \quad (5)$$

$$P_{kk}(1)=1-w_k(1) \quad (6)$$

Therefore the total number of promotions and recruitment is obtain from equations (5) and (6) as

$$P_{(k-1)k}(1)\,N_{k-1}(1)+R_k(1)=N_k(2)-N_k(1)\left[1-w_k(1)\right]$$
$$=N_k^{'}(2)\,(\text{Say}) \; (7)$$

Since number of promotions and recruitments are in the ratio $e_k:(1-e_k)$

we have

$$P_{(k-1)k}(1)\,N_{k-1}(1)=e_k N_k^{'}(2) \quad (8)$$

$$R_k(1)=(1-e_k)\,N_k^{'}(2) \quad (9)$$

Equation (8) and (9) gives number of promotions from grade (k-1) to grade k and the number of new recruits to grade k respectively. From equation (8)

$$P_{(k-1)k}(1)=\frac{e_k N_k^{'}(2)}{N_{k-1}(1)} \quad (10)$$

In equation (3), t = 1 and j = k-1 yields

$$P_{(k-1)(k-1)}(1)=1-w_{k-1}(1)-P_{(k-1)k}(t) \quad (11)$$

Proceeding in the similar manner for variations in j, the number of promotions and recruitment and the transition probability can be estimated for all other states of the system at various time points.

Data Analysis

There are four grades in Automation System Engineering private limited. Staff who designation are Engineer sales (state – 1), Senior Engineer sales (state – 2) , Manager sales/ Business development Manager (state – 30 and General Manager (state – 4). The numbers for $N_i(t)$ corresponds to the year 2012 (t = 1) and 2013 (t = 2). The existing staff structure N(1), the requirement for the next period N(2) and the wastage factor W(1) are as follows:

$$N(1)=\begin{bmatrix}5\\3\\4\\1\end{bmatrix} \quad N(2)=\begin{bmatrix}9\\5\\5\\1\end{bmatrix} \text{ and } \quad W(1)=\begin{bmatrix}0.8\\0.66\\0.25\\0\end{bmatrix}$$

Suppose promotions and recruitments are to be in ratio 0.3:0.7 for grade 2, 0.6: 0.4 for grade 3 and 0.8: 0.2 for grade 4.

Hence e_2 = 0.3, e_3 = 0.6 and e_4 = 0.8.

Transition probability for 3 to 4

$P_{44}=1-W_4(1)$ = 1 – 0 = 1

Now,

$P_{34}(1)N_3(1)+R_4(1)=N_4(2)-N_4(1)[1-W_4(1)]$

$4\,P_{34}(1)+R_4(1)$ = 1 – 1 (1 – 0) = 1 – 1 = 0 = $N_4^{'}(2)$

$e_4\,N_4^{'}(2)=$ (0.8) (0) = 0

$R_4(1)=(1-e_4)\,N_4^{'}(2)$ = (0.2) (0) = 0

$P_{34}(1)=\dfrac{e_4 N_4^{'}(2)}{N_3(1)}=\dfrac{1}{4}$ = 0.25

$P_{33}=1-W_3(1)-P_{34}(1)$ = 1 – 0.25 – 0.25 = 0.5

Transition probability from grade 2 to 3.

$P_{23}(1)N_2(1)+R_3(1)=N_3(2)-N_3(1)[1-W_3(1)]$

$3\,P_{23}(1)+R_3(1)$ = 5 – 4 [1 – 0.25] = 5 – 4 (0.75) = 5 – 3 = 2 = $N_3^{'}(2)$

$R_3(1)=(1-e_3)\,N_3^{'}(2)$ = (0.4) (2) = 0.8 ≈ 1.

$P_{23}(1)=\dfrac{e_3 N_3^{'}(2)}{N_2(1)}=\dfrac{1}{3}=0.33$

$P_{22}=1-W_2(1)-P_{23}(1)$ = 1 – 0.66 – 0.33 = 0.01

Transition probability from grade 1 to 2.

$P_{12}(1)N_1(1)+R_2(1)=N_2(2)-N_2(1)[1-W_2(1)]$

$5\,P_{12}(1)+R_2(1)$ = 5 – 3 [1 – 0.66]

= 5 – 3 (0.34) = 5 – 1.02 = 3.98 ≈ 4 = $N_2^{'}(2)$

Number of persons to be promoted from grade 1 to 2 is

$e_2\,N_2^{'}(2)=$ (0.3) (4) = 1.2 ≈ 1

$R_2(1)=(1-e_2)\,N_2^{'}(2)$ = (0.7) (4) 2.8 ≈ 3

$P_{12}(1)=\dfrac{e_2 N_2^{'}(2)}{N_1(1)}=\dfrac{1}{5}$ = 0.2

$P_{11}=1-W_1(1)-P_{12}(1)$ == 1 – 0.8 – 0.2 = 0

$R_1(1)=$ 9 – 5 (0) = 9

The vector of number of staff to be newly recruited R(1) and transition probability matrix, P(1) are given by

$$R(1) = \begin{bmatrix} 9 \\ 3 \\ 1 \\ 0 \end{bmatrix} \text{ and } P(1) = \begin{bmatrix} 0 & 0.2 & 0 & 0 \\ 0 & 0.01 & 0.33 & 0 \\ 0 & 0 & 0.5 & 0.25 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Conclusion

With above analysis we can conclude that for achieving required manpower structure 20% ,33% and 25% of staff can be promoted from grade 1 to grade 2, grade 2 to grade 3 and grade 3 to grade 4 respectively. Finally the suitable number of employee can be improving the calculated system criteria. This research can be applied as a basic for other studies in the field of human resource planning. Because of time constrains and work extension only a small part of the organization. We can use bivarite distribution and can be estimate the cut – off levels for seniority and performance rating. The limitation of this study provides opportunities for future research.

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