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Stochastic Analysis of Manpower Levels Affecting Business with the Introduction of Detection Location Phase for Review and Recruitment

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Abstract

Objectives: To apply continuous time Markov chain to manpower planning of a business concern. **Methodology:** The overall time for the process of recruitment time is then hypo-exponential. The different states have been discussed under the assumption that transitions from adequateness to shortage and shortage to adequateness follow exponential distribution with different parameters. A derivation has been done to give an expression for rate of crisis under steady state ($C\infty$). Steady state cost has also been worked by assigning different costs for the parameters under different conditions. **Findings:** When the values of parameters increase, the crisis rate also increases. The cost of business is high if business is full and manpower is in shortage. The cost of business is least when the business is nil and manpower is in shortage. **Applications/ Improvements:** The modern trend in any business concern is that the manpower is volatile and the managements are also conscious of maintaining optimum manpower so there is every chance of business facing crises situation is possible. This particular aspect is the crux of the paper and gives the method of determining the rate of crises.

Keywords: Crisis State, Detection Location Phase, Manpower Planning

1. Introduction

The manpower management has undergone a radical change over a period of time. Education and job opportunities have made the manpower more volatile in any concern. The enormous growth in information technology presents enough scope for anybody to qualify in any discipline and seek most lucrative employment that fits one. In fact, one becomes globally fit to work in any part of the world and switch over to new jobs frequently for higher salary and better benefits. From employer's side, employ the most beneficial, skilled and knowledgeable people and retrench them giving valid reasons for such retrenchment with due compensation. So in any business concern, employees leaving the concern suddenly for various reasons and the employer suddenly retrenching employees for various reasons is quite common these days that this is bound to affect a concern. The employees may also leave giving proper notice in advance and the management may also shed employees in a systematic and gradual manner depending on its requirement. This will also affect the business concern. The business concern has to review situations of its growth and fall and accordingly employ new staff. For this it will take some time. After taking a decision recruitment process has to be carried out like giving advertisement, receive the applications, segregate them, send call letters, conduct written test followed by interview internally of throughout sourcing. So this will consume its own time.

Approach to manpower problems have been viewed in different angles and treated accordingly in very many different ways as early as 1947 and others[1]. Many manpower models with application of stochastic processes have been discussed[2,3]. Models to compute wastages (Resignation,

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dismissal and death) and promotion opportunities which produce the proportions corresponding to some desired level has been well discussed[4]. Markov models have been formulated for wastages and promotion in manpower system[5]. In [6] the thesis has given models to provide optimal policy for recruitment training, promotion, and wastages in manpower with special provisions such as time bound promotions, cost of training and voluntary retirement scheme. Application of Markov chains in a manpower system with efficiency and seniority and Stochastic structures of graded size in manpower planning systems has been well discussed[7]. For a system involving characteristics such as manpower, money and machine one may refer to[8]. Semi Markov Models for Manpower planning has been effectively dealt in the paper[9]. The concept of setting the clock back to zero property is effectively handled based on an analogy of how manpower affects business in different situations[10]. In this model, a business is considered with two levels of fluctuations namely the business is full (0) and the business is in shortage or nil (1). Manpower functions with full capacity, enters a detection location phase because of decrease in manpower and the next is final phase of recruitment.

2. System Analysis

The manpower functions with full capacity (0), it enters the detection location phase viz the phase of reduced strength (1) and it enters the final stage of recruitment (2) The steady state probabilities of the continuous Markov Chain that describes the transitions in various states are derived, critical states are identified to determine the rate of crisis under state conditions and arrive at the cost analysis. Numerical examples are provided.

2.1. Assumptions

The time for which the manpower remains continuously full and enters a state of reduced strength follows exponential distribution with parameter α The other two phases have exponential distribution with means 1/β and 1/γ The overall time for the process of recruitment time is then hypo-exponential. Since the sojourn time is in the down state is two - stage hypo-exponentially distributed, the system being modeled in a semi Markov process. The busy and lean periods of the business are exponentially distributed with parameters a and b.

The Stochastic Process X(t) describing the state has in its system six points and the system is a continuous time Markov chain and is as given below in the order where the first co-ordinate indicates business, the second co-ordinates indicate full manpower (0), detection location phase (1) and final stage of recruitment (2)

$$S = \{(0,0) \quad (0,1) \quad (0,2) \quad (1,0) \quad (1,1) \quad (1,2)\} \qquad (1)$$

The infinitesimal generator Q of the continuous Markov chain of the state space is given below which is a matrix of order 6.

B/M	(0 0)	(0 1)	(0 2)	(1 0)	(1 1)	(1 2)	(2)
(0 0)	€1	α	0	b	0	0	
(0 1)	0	€2	β	0	b	0	
(0 2)	γ	0	€3	0	0	b	
(1 0)	a	0	0	€4	α	0	
(1 1)	0	a	0	0	€5	β	
(1 2)	0	0	a	γ	0	€6	

where, $€_1 = -(\alpha + b)$, $€_2 = -(\beta + b)$, $€_3 = -(\gamma + b)$, $€_4 = -(\alpha + a)$ $€_5 = -(\beta + a)$, $€_6 = -(\gamma + a)$

The occurrences of transitions in both manpower and business are independent. The individual infinitesimal generator of them is given by:

1. Infinitesimal generator of Manpower:

	M	0	1	2
	0	-α	α	γ
M =	1	0	-β	β
	2	γ	0	-γ

The steady state probabilities of Manpower are:

$$\pi_{oM} = \frac{1}{1+\frac{\alpha}{\beta}+\frac{\alpha}{\gamma}} \qquad \pi_{1M} = \frac{\alpha}{\beta\left(1+\frac{\alpha}{\beta}+\frac{\alpha}{\gamma}\right)}$$

$$\pi_{2M} = \frac{\alpha}{\gamma\left(1+\frac{\alpha}{\beta}+\frac{\alpha}{\gamma}\right)}$$

The infinitesimal generator of business is a matrix of order 2 and is given below:

	B	0	1
B =	0	-a	a
	1	b	-b

The steady state probabilities are $\pi_{0B} = \frac{a}{a+b}$ and $\pi_{1B} = \frac{b}{a+b}$

The steady state probability vector of the matrix Q can be derived using the equations

π_Q = 0 and π_e = 1

$$\pi_{o0} = \frac{a}{X}\frac{1}{Y} \qquad \pi_{o1} = \frac{a}{X}\frac{\alpha}{\beta Y} \qquad \pi_{o2} = \frac{a}{X}\frac{\alpha}{\gamma Y}$$

$$\pi_{10} = \frac{b}{X}\frac{1}{Y} \qquad \pi_{11} = \frac{b}{X}\frac{\alpha}{\beta Y} \qquad \pi_{12} = \frac{a}{X}\frac{\alpha}{\gamma Y}$$

where, X = (a + b) and Y = ($Y = \left(1+\frac{\alpha}{\beta}+\frac{\alpha}{\gamma}\right)$)

When the business is fully available, enough manpower will be available and gets reduced as time pass by and enters the state of shortage thereafter review of situation takes place for period and then recruitment process takes place. The period when shortage of manpower is there but business is fully available is called the crisis situation.

A crisis state is one where the business is full but manpower is in shortage and is {(0, 1)}.

The rate of Crisis in steady state conditions is obtained as follows:

$$\text{P crisis in } (t+\Delta t) = pX(t+\Delta t) = (0\ 1)/X(t) = (1\ 1)xpX(t) = (1\ 1)$$
$$+pX(t+\Delta t) = (0\ 1)/X(t) = (0\ 0)xpX(t) = (0\ 0)$$
$$+O\Delta\tau$$

Taking limit as $\Delta t \to 0,$ gives

$$C_t = ap_{11}(t) + p_{00}(t) \text{ Now } t \to \infty, \text{ leads to}$$

$$C_\infty = a\pi_{11} + \alpha\pi_{00} = \frac{a}{X}\frac{\alpha}{Y}\frac{b}{\beta} \tag{4}$$

3. Numerical Illustration

Different values for the parameters are assigned to obtain numerical values for the steady state probabilities, crisis state and the steady state cost,

Taking α = 19, β = 5, γ = 7. a = 20 and b = 15 the steady state probabilities are obtained using (3)

$$\pi_{o0} = 0.1290 \qquad \pi_{o1} = 0.2580 \qquad \pi_{o2} = 0.1843$$
$$\pi_{10} = 0.0968 \qquad \pi_{11} = 0.1936 \qquad \pi_{12} = 0.1383$$

Now assigning the values a = 20, 30, 40, 50 and 60 in (4). The rate of crisis is calculated and are presented in Table 1. The pictorial representation is given in Figure 1.

Table 1. The relationship between a and C∞

a	C_∞
20	20.64
30	24.08
40	26.27
50	27.79
60	28.90

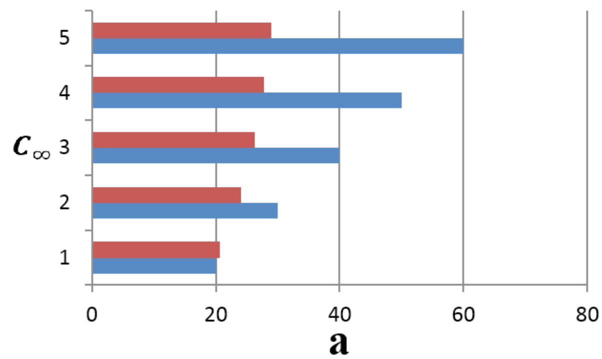

Figure 1. Pictorial representation for the parameters a and C∞.

By assigning the values α = 30, 25, 20, 15 and 5 in (4). The rate of crisis is calculated and are presented in Table 2. The pictorial representation is given in Figure 2.

The steady cost is determined using the formula

$$C_{IJ} = \pi_{IJ} = C_M^i + C_B^j \cdots \tag{5}$$

The steady state costs in different situations are determined by taking the values

$C_M{}^0 = 25, C_M{}^1 = 15, C_M{}^2 = 10, C_B{}^0 = 15, C_B{}^1 = 8,$ using (5)

The cost analysis for the various probabilistic states is presented in Table 3.

From the Table 1 and 2, it is observed that as the values of parameters a and α increase the crisis rate also increase. Further, it is observed from the Table 3 that the cost of business is heavy if business is full and manpower is in shortage. The cost of business is least when the business is nil and manpower is in shortage.

Table 2. The relationship between α and C∞

α	C_∞
30	24.30
25	23.88
20	23.27
15	22.32
5	16.84

Table 3. Cost Analysis.

S.No	Steady state probability	Cost of state
1	$\pi_{o\,0}$	5.16
2	$\pi_{o\,1}$	7.74
3	$\pi_{o\,2}$	4.60
4	$\pi_{1\,0}$	3.19
5	π_{11}	4.45
6	π_{12}	2.49
	Total	27 .63

4. Conclusions

Four stages are envisaged in this manpower model. Detection location phase is introduced and then the final stage of recruitment. The overall time for the processes is assumed to follow hypo exponential distribution and with different parameters following exponential distribution. Steady state probabilities are found; the respective cost are determined. This is entirely a new model which is prevalently followed in many business concerns.

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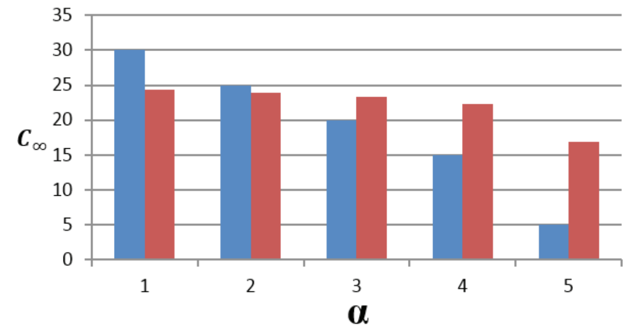

Figure 2. Pictorial representation for the parameters α and C∞.

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