TIME TO RECRUITMENT FOR A TWO GRADE MANPOWER SYSTEM UNDER TWO SOURCES OF DEPLETION OF MANPOWER USING UNIVARIATE MAX POLICY OF RECRUITMENT BASED ON SHOCK MODEL APPROACH

S.Dhivya[1] and A.Srinivasan[2]

[1]Assistant Professor, Department of Mathematics, Srinivasan Engineering College, Perambalur, Tamil Nadu, India- 621 212.

[2]Professor Emeritus, PG & Research department of Mathematics, Bishop Heber College, Trichy, Tamil Nadu, India -17.

ABSTRACT

Depletion of manpower due to attrition of personnel is a common phenomenon in any marketing organization when the management takes policy decisions regarding pay, perquisites and work targets. This depletion will lead to breakdown of the organization in due course of time if it is not compensated by recruitment. Since the depletion of manpower as a consequence of the inter-decision times is unpredictable and frequent recruitment which involves more cost is not advisable, the organization requires a suitable recruitment policy to plan for recruitment. In this paper, the problem of time to recruitment for a two grade manpower system with two sources for depletion of manpower is studied by constructing two mathematical models and using a univariate ***max*** *policy of recruitment based on shock model approach. Analytical results for some performance measures related to time to recruitment are obtained for both the models. The results are numerically illustrated by assuming specific distributions and relevant findings are presented.*

Keywords: Performance measures for time to recruitment, Shock model approach, Two grade manpower system, Two sources for depletion**,** Univariate **max** policy of recruitment.

1. Introduction

Early studies related to manpower planning were reported by a number of researchers namely Young and Almond [1], Pollard [2], Bartholomew and Morries [3],Young and Vassiliou [4], Grinold [5], Grinold and Marshall [6], Vajda [7], Mukherjee and Chattopadhyay [8], Rao and Talwalker [9], Poornachandra Rao [10], Ragavendra [11] and so on. In these articles, discussion is given on the description of the manpower system, historical development of the system, elementary theory of wastages and their measures. Bartholomew

[12] and Bartholomew and Forbes [13] have discussed some manpower planning models for single and multi grade manpower system using markovian and renewal theoretic approach. Many researchers [14], [15]&[16] have studied the problem of time to recruitment for single and two grade manpower system using univariate and bivariate policies of recruitment by considering policy decisions as the only one source for depletion of man power. Esther Clara and Srinivasan [14] have studied the problem of time to recruitment for a single grade manpower system with optional and mandatory thresholds for random loss of manpower using univariate **max** policy of recruitment when the inter-decision times are exchangeable and constantly correlated exponential random variables. Elangovan et.al [17] have initiated the study on the problem of time to recruitment for a single grade manpower system with **two sources of depletion**, one source being the policy decisions and other being the transfer decisions, and obtained the variance of time to recruitment using univariate CUM policy of recruitment with independent exponential breakdown threshold for the total loss of manpower when the loss of man power in the organization due to the two sources of depletion, inter-policy decision times, inter-transfer decision times, each forming a sequence of independent and identically exponential random variables with different means. Recently, Dhivya and Srinivasan [18] and [19] have extended the work of Elangovan et.al [17] for a two grade manpower system under different conditions on the inter-policy decisions, inter-transfer decisions and thresholds for the cumulative loss of manpower in each grade. The objective of the present paper is to study the authors own works [18] & [19] using univariate **max** policy of recruitment.

2. Model description of Model I:

Consider an organization taking decisions at random epoch $(0,\infty)$ and at every decision making epoch a random number of persons quit the organization. There is an associated loss of manpower if a person quits. It is assumed that the loss of manpower is linear and cumulative. For i=1,2,3…,let X_i be the continuous random variables representing the amount of depletion of manpower(loss of man hours) caused due to the ith policy decision in the organization. It is assumed that X_i form a sequence of independent and identically distributed random variables with distribution $G(.)$. Let $\bar{X}_m$ be the maximum loss of manpower due to the first m policy decisions in the organization. For j=1,2,3…,let Y_j be the continuous random variables representing the amount of depletion of manpower in the organization caused due to the j^th transfer decision. It is assumed that Y_j form a sequence of independent and identically distributed random variables with probability distribution function $H(.)$. Let $\bar{Y}_n$ be the maximum loss of manpower in the organization due to the first n transfer decisions. For each i and j, X_i and Y_j are statistically independent. Let C $(C > 0)$ be the constant breakdown threshold level for the depletion of manpower in the organization. Let the inter-policy decision times be independent and identically distributed exponential random variables with distribution $F(.)$ and mean $\frac{1}{\mu_1}(\mu_1 > 0)$. Let the inter-transfer decision times be independent and identically distributed exponential random variables with distribution $W(.)$and mean $\frac{1}{\mu_2}(\mu_2 > 0)$. It is assumed that the two sources of depletion are independent. Let $F_m(.)$be the m-fold convolution of F$(.)$with itself and $W_n(.)$ be the n-fold convolution of $W(.)$ with itself. Let T be the random variable denoting the time to recruitment with distribution L(.), mean E(T) and variance V(T). Let $N_P(T)$be the number of policy decisions required to make recruitment at T and $N_{Trans.}(T)$ be the number of transfer decisions required to make recruitment at T. The univariate **max** policy of recruitment employed in this paper is stated as follows:

Recruitment is done whenever the maximum loss of man hours in the organization exceeds C.

3. Main Results for model I:

$$P(T > t) = \sum_{m=0}^{\infty}\sum_{n=0}^{\infty}\left\{\begin{matrix} Probability\ that\ there\ are\ exactly\ m\ policy\ decisions\ and\ n\ transfer \\ decisions\ in\ [0,t) and\ the\ maximum\ loss\ of\ manhours\ due\ to\ m\ policy \\ decisions\ and\ n\ transfer\ decisions\ does\ not\ exceed\ the\ threshold\ C \end{matrix}\right\}$$

By using laws of probability and from renewal theory [20],

$$P(T > t) = \sum_{m=0}^{\infty}[F_m(t) - F_{m+1}(t)]\sum_{n=0}^{\infty}[W_m(t) - W_{m+1}(t)]P(\max(\bar{X}_m, \bar{Y}_n) \le C) \quad (1)$$

where $F_0(t) = W_0(t) = 1$.

Since

$$P(\max(\bar{X}_m, \bar{Y}_n) \le C) = [G(C)]^m[H(C)]^n \quad (2)$$

from (1), (2) and on simplification we get

$$P(T > t) = \{1 - [1 - G(C)]\sum_{m=1}^{\infty} F_m(t)[G(C)]^{m-1}\} X \{1 - [1 - H(C)]\sum_{n=1}^{\infty} W_n(t)[H(C)]^{n-1}\} \quad (3)$$

From the hypothesis we note that $f_m(t) = \frac{{\mu_1}^m e^{-\mu_1 t} t^{m-1}}{(m-1)!}$ and $w_n(t) = \frac{{\mu_2}^n e^{-\mu_2 t} t^{n-1}}{(n-1)!}$.

Therefore we find that

$$[1 - G(C)]\sum_{m=1}^{\infty} F_m(t)[G(C)]^{m-1} = 1 - e^{-\mu_1[1-G(C)]t}$$

and

$$[1-H(C)]\ \sum_{n=1}^{\infty} W_n(t)[H(C)]^{n-1} = 1-e^{-\mu_2[1-H(C)]t} \quad (4)$$

From (3) and (4) we get

$$L(t) = 1-e^{-[\mu_1[1-G(C)]+\mu_2[1-H(C)]]t} \quad (5)$$

which is an exponential distribution with parameter $\mu_1[1-G(C)]+\mu_2[1-H(C)]$.

We now obtain several performance measures from (5).

i. $E(T) = \frac{1}{\mu_1[1-G(C)]+\mu_2[1-H(C)]}$

ii. $V(T) = \frac{1}{[\mu_1[1-G(C)]+\mu_2[1-H(C)]]^2}$

iii. Hazard rate at T = $\mu_1[1-G(C)]+\mu_2[1-H(C)]$

iv. Probability that recruitment takes place in (t, t+dt) given that there is no recruitment in [0,t]

$=P(t<T<t+dt/T>t) = \left[1-e^{-[\mu_1[1-G(C)]+\mu_2[1-H(C)]]dt}\right]$

v. Average residual time for recruitment given that there is no recruitment upto time t.

$= E(T-t/T>t) = \frac{1}{\mu_1[1-G(C)]+\mu_2[1-H(C)]}$

vi. Average number of policy and transfer decisions required to make recruitment at T= $(\mu_1+\mu_2)E(T)$

vii. Average total loss of manpower due to $N_P(T)$ and $N_{Trans.}(T)$ decisions

$=\{\mu_1[E(X_i)]+\mu_2[E(Y_j)]\}E(T)$

Special Case:

Suppose X_i *and* Y_j follow exponential distribution with parameters α_1 and α_2 respectively.

In this case $E(T) = \frac{1}{\mu_1 e^{-\alpha_1 C}+\mu_2 e^{-\alpha_2 C}}$ and $V(T) = \frac{1}{[\mu_1 e^{-\alpha_1 C}+\mu_2 e^{-\alpha_2 C}]^2}$. The other performance measures in (iii)-(vii) can easily be obtained.

4. Model description of Model II:

In Model I, focusing on the characteristics namely loss of manpower, inter-policy decision times and inter-transfer decision times is made not upon the two grades separately, but on the organization as a single entity. More specifically, in model I, the inter-policy decision times (the inter-transfer decision times) for the two grades form the same ordinary renewal process. In the present model, the above cited characteristics are focused grade wisely and the inter-policy decision times (the inter-transfer decision times) for the two grades form different renewal processes. For i=1,2,3…,let X_{Ai} and X_{Bi} be the continuous random variables representing the amount of depletion of manpower(loss of man hours) in grades A and B respectively caused due to the i[th] policy decision. It is assumed that X_{Ai} and X_{Bi} are independent for each i and each form a sequence of independent and identically distributed random variables with distributions $G_A(.)$ and $G_B(.)$ respectively. Let $\bar{X}_{Am_1}$ and $\bar{X}_{Bm_2}$ be the maximum loss of manpower in the first m_1 and m_2 policy decisions in grades A and B respectively. For j=1,2,3…,let Y_{Aj} and Y_{Bj} be the continuous random variables representing the amount of depletion of manpower in grades A and B respectively caused due to the j[th] transfer decision. It is assumed that Y_{Aj} and Y_{Bj} are independent for each j and each form a sequence of independent and identically distributed random variables with distributions $H_A(.)$ and $H_B(.)$ respectively. Let $\bar{Y}_{An_1}$ and $\bar{Y}_{Bn_2}$ be the maximum loss of manpower in the first n_1 and n_2 transfer decisions in grades A and B respectively. For each i and j, X_{Ai}, X_{Bi}, Y_{Aj} and Y_{Bj} are statistically independent. Let the inter-policy decision times for grades A and B be independent and identically distributed exponential random variables with distribution $F(.)$ and U(.) and mean $\frac{1}{\mu_{1A}}$ and $\frac{1}{\mu_{1B}}$ $(\mu_{1A}, \mu_{1B} > 0)$ respectively. Let the inter-transfer decision times for grades A and B be independent and identically distributed exponential random variables with distribution $W(.)$ and V(.) and mean $\frac{1}{\mu_{2A}}$ and $\frac{1}{\mu_{2B}}$ $(\mu_{2A}, \mu_{2B} > 0)$ respectively. It is assumed that the two sources of depletion are independent. All the other assumptions are same as in model I.

Main results for model II

By using laws of probability and from renewal theory[10],

$$P(T > t) = \sum_{m_1=0}^{\infty}[F_{m_1}(t) - F_{m_1+1}(t)] \sum_{n_1=0}^{\infty}[W_{n_1}(t) - W_{n_1+1}(t)] \sum_{m_2=0}^{\infty}[U_{m_2}(t) - U_{m_2+1}(t)]$$
$$X \sum_{n_2=0}^{\infty}[V_{n_2}(t) - V_{n_2+1}(t)] P\left(\max(\bar{X}_{Am_1}, \bar{Y}_{An_1}, \bar{X}_{Bm_2}, \bar{Y}_{Bn_2}) \le C\right) \tag{6}$$

where

$$P\left(\max(\bar{X}_{Am_1}, \bar{Y}_{An_1}, \bar{X}_{Bm_2}, \bar{Y}_{Bn_2}) \le C\right) = [G_A(C)]^{m_1}[H_A(C)]^{n_1}[G_B(C)]^{m_2}[H_B(C)]^{n_2} \tag{7}$$

From (6), (7) and on simplification we get

$$P(T > t) = \{1 - [1 - G_A(C)] \sum_{m_1=1}^{\infty} F_{m_1}(t)[G_A(C)]^{m_1-1}\} X \{1 - [1 - H_A(C)] \sum_{n_1=1}^{\infty} W_{n_1}(t)[H_A(C)]^{n_1-1}\}$$
$$X\{1 - [1 - G_B(C)] \sum_{m_2=1}^{\infty} U_{m_2}(t)[G_B(C)]^{m_2-1}\} X \{1 - [1 - H_B(C)] \sum_{n_2=1}^{\infty} V_{n_2}(t)[H_B(C)]^{n_2-1}\} \tag{8}$$

Since $f_m(t) = \frac{{\mu_1}^m e^{-\mu_1 t} t^{m-1}}{(m-1)!}$ and $w_n(t) = \frac{{\mu_2}^n e^{-\mu_2 t} t^{n-1}}{(n-1)!}$ by hypothesis, we find that

$$[1 - G_A(C)] \sum_{m_1=1}^{\infty} F_{m_1}(t)[G_A(C)]^{m_1-1} = 1 - e^{-\mu_{1A}[1-G_A(C)]t}$$

$[1-G_B(C)]\sum_{m_2=1}^{\infty}U_{m_2}(t)[G_B(C)]^{m_2-1}=1-e^{-\mu_{1B}[1-G_B(C)]t}$

$[1-H_A(C)]\sum_{n_1=1}^{\infty}W_{n_1}(t)[H_A(C)]^{n_1-1}=1-e^{-\mu_{2A}[1-H_A(C)]t}$

and

$[1-H_B(C)]\sum_{n_2=1}^{\infty}V_{n_2}(t)[H_B(C)]^{n_2-1}=1-e^{-\mu_{2B}[1-H_B(C)]t}$ (9)

Therefore from (8) and (9) we get

$L(t)=1-e^{-\left[\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]\right]t}$ (10)

which is an exponential distribution with parameter $\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]$.

We now obtain several performance measures from (10).

i. $E(T)=\frac{1}{\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]}$

ii. $V(T)=\frac{1}{\left[\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]\right]^2}$

iii. Hazard rate at T = $\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]$

iv. Probability that recruitment takes place in (t, t+dt) given that there is no recruitment in [0,t]=$P(t<T<t+dt/T>t)$=$\left[1-e^{-[\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]]dt}\right]$

v. Average residual time for recruitment given that there is no recruitment upto time t.

$=E(T-t/T>t)=\frac{1}{\mu_{1A}[1-G_A(C)]+\mu_{2A}[1-H_A(C)]+\mu_{1B}[1-G_B(C)]+\mu_{2B}[1-H_B(C)]}$

vi. Average number of policy and transfer decisions required to make recruitment at T

=$(\mu_{1A}+\mu_{2A}+\mu_{1B}+\mu_{2B})E(T)$

vii. Average total loss of manpower due to $N_P(T)$and $N_{Trans.}(T)$decisions

= $\{\mu_{1A}E(X_{Ai})+\mu_{1B}E(X_{Bi})+\mu_{2A}E(Y_{Aj})+\mu_{2B}E(Y_{Bj})\}E(T)$

Special Case:

Suppose X_{Ai}, X_{Bi}, Y_{Aj} *and* Y_{Bj} follow exponential distribution with parameters α_{1A}, α_{1B}, α_{2A} and α_{2B} respectively.

In this case $E(T)=\frac{1}{\mu_{1A}e^{-\alpha_{1A}C}+\mu_{1B}e^{-\alpha_{1B}C}+\mu_{2A}e^{-\alpha_{2A}C}+\mu_{2B}e^{-\alpha_{2B}C}}$ and $V(T)=\frac{1}{[\mu_{1A}e^{-\alpha_{1A}C}+\mu_{1B}e^{-\alpha_{1B}C}+\mu_{2A}e^{-\alpha_{2A}C}+\mu_{2B}e^{-\alpha_{2B}C}]^2}$

Note:

Suppose $X_{ij}=\max(X_{Ai},X_{Bj})$, $\bar{X}_{m_1,m_2}=\max_{\substack{1\le i\le m_1\\1\le j\le m_2}}(X_{ij})$, $Y_{kl}=\max(Y_{Ak},Y_{Bl})$ and $\bar{Y}_{n_1,n_2}=\max_{\substack{1\le k\le n_1\\1\le l\le n_2}}(Y_{kl})$.

For this X_{ij} and Y_{kl},

$P\left(\max(\bar{X}_{m_1,m_2},\bar{Y}_{n_1,n_2})\le C\right)=[G_A(C)]^{m_1}[H_A(C)]^{n_1}[G_B(C)]^{m_2}[H_B(C)]^{n_2}$.

Therefore the performance measures for this choice of X_{ij} *and* Y_{kl} are same as in model II.

5. Numerical Illustration:

The mean and variance of time to recruitment for both the models are numerically illustrated by varying one parameter and keeping all the other parameters fixed.

α_1	α_2	μ_1	μ_2	C	$E(T)$	$V(T)$
0.1	1.5	0.9	0.7	2.25	1.3466	1.833
0.3	1.5	0.9	0.7	2.25	2.0739	4.3009
0.5	1.5	0.9	0.7	2.25	3.1032	10.0056
1.5	0.1	0.9	0.7	2.25	1.6956	2.8751
1.5	0.3	0.9	0.7	2.25	2.5826	6.6699
1.5	0.5	0.9	0.7	2.25	3.8752	15.0170
1.5	0.9	0.1	0.7	2.5	13.1352	172.5338
1.5	0.9	0.3	0.7	2.5	12.3709	153.0395
1.5	0.9	0.5	0.7	2.5	11.6907	136.6717
1.5	0.4	0.7	0.1	2.5	18.7792	352.6589
1.5	0.4	0.7	0.3	2.5	7.8848	62.1701
1.5	0.4	0.7	0.5	2.5	4.9900	24.8998

Table 1

Model I

Table 2

Model II

(μ_{1A}=0.7, μ_{1B}=0.2, μ_{2A}=1.5, μ_{2B}=0.8, C=1.5)

μ_{1A}	μ_{1B}	μ_{2A}	μ_{2B}	$E(T)$	$V(T)$
0.1	0.2	1.5	0.8	0.7371	0.5433
0.3	0.2	1.5	0.8	0.7258	05268
0.5	0.2	1.5	0.8	0.7149	0.5110
0.2	0.1	1.5	0.8	0.7620	0.5806
0.2	0.3	1.5	0.8	0.7032	0.4945
0.2	0.5	1.5	0.8	0.6528	0.4261
0.2	1.5	0.1	0.8	0.8417	0.7085
0.2	1.5	0.3	0.8	0.7601	0.5778
0.2	1.5	0.5	0.8	0.6930	0.4802
0.2	1.5	0.8	0.1	0.7197	0.5180

Table 3

Model II

(α_{1A}=1.5, α_{1B}=0.4, α_{2A}=0.3, α_{2B}=0.7, C=1.5)

α_{1A}	α_{1B}	α_{2A}	α_{2B}	$E(T)$	$V(T)$
0.1	1.5	0.4	0.3	0.5110	0.2611
0.3	1.5	0.4	0.3	0.5553	0.3084
0.5	1.5	0.4	0.3	0.5935	0.3522
1.5	0.1	0.4	0.3	0.6332	0.4010
1.5	0.3	0.4	0.3	0.6516	0.4246
1.5	0.5	0.4	0.3	0.6660	0.4435
1.5	0.4	0.1	0.3	0.5039	0.2539
1.5	0.4	0.3	0.3	0.6060	0.3673
1.5	0.4	0.5	0.3	0.7132	0.5086
1.5	0.4	0.3	0.1	0.5469	0.2991
1.5	0.4	0.3	0.3	0.6060	0.3673
1.5	0.4	0.3	0.5	0.6588	0.4340

0.2	1.5	0.8	0.3	0.6852	0.4695
0.2	1.5	0.8	0.5	0.6539	0.4275

Findings:

From the above tables the following inference are presented which agree with reality,

i. When α_1 and α_2 increase separately and keeping all the other parameters fixed in table 1, the mean and variance of time to recruitment increase.
ii. When μ_1 and μ_2 increase separately and keeping all the other parameters fixed in table 1, the mean and variance of time to recruitment decrease.
iii. When $\alpha_{1A}, \alpha_{1B}, \alpha_{2A}$ and α_{2B} increase separately and keeping all the other parameters fixed in table 2, the mean and variance of time to recruitment increase.
iv. When $\mu_{1A}, \mu_{1B}, \mu_{2A}$ and μ_{2B} increase separately and keeping all the other parameters fixed in table 3, the mean and variance of time to recruitment decrease.

6. Conclusion:

The manpower planning model developed in this paper can be used to plan for the adequate provision of manpower for the organization at graduate, professional and management levels in the context of attrition. There is a scope for studying the applicability of the designed model using simulation. Further, by collecting relevant data, one can test the goodness of fit for the distributions assumed in this paper. The findings given in this paper enable one to estimate manpower gap in future, thereby facilitating the assessment of manpower profile in predicting future manpower development not only on industry but also in a wider domain.

References:

[1] A.Young and G.Almond, Predictions of distributions of staff, *Computer Journal, 3, 1961, 246-250.*

[2] J.H.Pollard, Hierarchical population models with Poisson recruitment, *J. Appl. Probability, 4, 1967, 209-213.*

[3] D.J.Bartholomew, and B.R.Morries, Aspects of Manpower Planning, *Elsevier Publishing Company, New York, 1971.*

[4] A.Young and P.C.G.Vassiliou, A non-linear model on the promotion of staff, *Journal of Royal Statistical Society, A137, 1974, 584-595.*

[5] R.C.Grinold, Manpower planning with uncertain recruitments, *Operations Research, 24, 1976, 387-400.*

[6] R.C.Grinold, and K.T.Marshall, Manpower Planning Models (*North Holland, New York, 1977*).

[7] S.Vajda, Mathematics of Manpower Planning (*John Wiley, Chichester, 1978*).

[8] S.P.Mukherjee, and A.K.Chattopadhyay, An optimal recruitment policy, *Indian Association for Productivity Quality and Reliability Transactions, 11(1-2), 1985, 87-96.*

[9] B.R.Rao, and S.Talwalker, Setting the Clock Back to Zero Property of a class of the life distribution, *The Journal of Statistical Planning and Inference, 24, 1990, 347-352.*

[10] P.Poornachandra Rao, A dynamic programming approach to determine optimal manpower recruitment policies, *J. Opl. Res. Soc.,41, 1990, 983-988.*

[11] B.G.Ragavendra, A bivariate model for Markov manpower planning systems, *J. Opl. Res. Soc., 42(7),1991, 565-570.*

[12] D.J.Bartholomew, Renewal theory models in manpower planning, *Symposium Proceedings Series No. 8, The Institute of Mathematics and its Applications, 1976a, 57-73.*

[13] D.J.Bartholomew, and A.F. Forbes, Statistical Technique for Manpower Planning (*John Wiley, Chichester, 1979*).

[14] J.B.Esther Clara and A.Srinivasan, A stochastic model for the expected time to recruitment in a single graded manpower system with two thresholds using univariate MAX policy, *Applied Mathematical Sciences, 5(34), 2011, 1693–1704.*

[15] R.Sathiyamoorthi and S.Parthasarathy, On the expected time to recruitment in a two graded marketing organization, *Indian Association for Productivity Quality and Reliability,27(1), 2002, 77-81*

[16] R.Suresh Kumar, G.Gopal and R.Sathiyamoorthi, Stochastic models for the expected time to recruitment in an organization with two grades, *International Journal of Management and systems, 22(2), 2006, 147-164.*

[17] R.Elangovan, R.Sathiyamoorthi and E.Susiganeshkumar, Estimation of expected time to recruitment under two sources of depletion of manpower, *Proceedings of the International Conference on Stochastic Modelling and Simulation, Allied Publishres Pvt.Ltd.,Chennai, 2011, 99-104.*

[18] S.Dhivya, and A.Srinivasan, Stochastic model for time to recruitment Under two sources of depletion Of manpower using univariate Policy of recruitment, *International J. of Multidispl. Research & Advcs. in Engg, 5(4), 2013,17-26.*

[19] S.Dhivya and A.Srinivasan, Stochastic model for time to recruitment under two Sources of depletion of manpower associated with different renewal process, *International Journal of Revolution in Science and Humanity, 2(1), 2013, 45-51.*

[20] Karlin, Samuel and Taylor, M.Haward., A First Course in Stochastic Processes, (*New York, NY:Academic Press, Second Edition, 1975*).