PREDICTING THE EXPECTED TIME IN AN ORGANIZATION THROUGH TRANSMUTED LINDLEY DISTRIBUTION

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Abstract

Manpower modeling of an organization can generally be divided into a number of classes that are exhaustive, mutually exclusive, and homogeneous groups. Manpower planning assesses current levels and utilization of staff and skills, relates these elements to the market demand for the organizations products and provides alternatives to match manpower resources with anticipated demand. The theory developed was tested using stimulated data in MathCAD software. To illustrate the method described in this paper, authors give some limited simulation results. The expected time observed that as the expected states in the inter arrival ‘c’ increases the parameter fix shows there is a decrease in the organization.

Keywords: Transmuted Lindley Distribution, Expected time, Inter arrival time, Organization and Recruitment.

INTRODUCTION

A manpower model is a statistical analysis of the organization's ability to adapt to change. A manpower model is a mathematical explanation of how system change occurs. The main focus of any management of human resources development is manpower modeling. Stochastic modeling is required for the development and analysis of the personnel system due to the uncertainties inherent in the ongoing process of manpower models. To fit the manpower systems across various businesses, many researchers have created several manpower models with significant diversity. Manpower modeling of an organization can generally be divided into a number of classes that are exhaustive, mutually exclusive, and homogeneous groups. A grade, pay level, age group, or any other classification or combination of classifications of interest may be reflected in the classes. In the system as a whole, between classes within the system, and between the system and other sources of employment or beyond the system, flows are meant to occur. (2017)[23].

Some of the generalizations or modification of the distribution include: the discrete Poisson-Lindley distribution[21], three parameter generalization of the one parameter Lindley distribution (2009)[13], size-biased Poisson Lindley distribution[18], negative binomial-Lindley distribution (2010)[14], discrete Lindley distribution (2011)[6], two parameter weighted Lindley distribution (2011)[20], an extended Lindley distribution (2012)[12]. Power Lindley distribution (2013)[19] and generalized Lindley distribution (2011)[28]. Also available are: transmuted Lindley distribution (2013)[9], two parameter quasi Lindley distribution (2013)[24], Kumaraswamy Quasi Lindley (2013)[15], transmuted Quasi Lindley distribution (2013)[16], beta-Lindley distribution (2014)[8], inverse Lindley distribution (2015)[31], truncated Lindley distribution (2014)[27], Pareto Poisson–Lindley distribution (2013)[1], Log-Lindley distribution (2014)[7], generalized Power Lindley distribution (2014)[11], a new generalization of the distribution based on the probabilistic mixture of two gamma distributions (2015)[3] and Lindley exponential distribution (2015)[5] – (2016)[22].

BACKGROUND OF THE STUDY

With the rapid development of economy and increasing globalization, manpower planning has become a critical issue for human resource department in today's competitive world, especially for the international corporations and large organizations. It requires developing an optimal management strategy to match the requirement of the staffs and the available positions for achieving specific goals. However, there are many indeterminate factors that should be taken into consideration in manpower planning, such as labor demand, working life and economic environment. At present, many different stochastic manpower planning models. Chattopadhyay and Gupta (2007)[2] developed a stochastic manpower planning model under the setup, where the survival rates and the number of workers at different ages are treated as random variables. S.Yan et.al., (2008)[30], discussed two long-term stochastic demand planning models for air cargo terminal manpower supply planning in long-term operations, where the labor demand is described as a random variable. Young and Vassiliou (1974)[4]. Considered a non-linear stochastic model of hierarchically structured management staffs in commercial and industrial organizations, where the promotion of employees is modeled as a random variable.

Manpower planning assesses current levels and utilization of staff and skills, relates these elements to the market demand for the organizations products and provides alternatives to match manpower resources with anticipated demand. It is a dynamic process, which manages the flow of labour into, through and out of the organization, to achieve an optimum match. Manpower planning is the systematic approach to the utilization of available manpower according to the demands that exist in different sectors of the country. Hence, manpower models are developed taking into consideration the various real life situations. Manpower is a term, which means a group of persons who have acquired some particular skill or expertization to undertake a particular type of job. Scientific methods of approach to economic problems and evolving suitable economic policies are important aspects of efficient administration. The reliability theory and replacement strategies can be combined together to decide suitable manpower policies. The application of this theory is considered in relation to manpower systems and suitable strategies for promotion as well as replacement of manpower for the successful maintenance of the system are discussed. Application of replacement strategies to manpower planning has been discussed by Robinson (1974)[26].

Table 1. Related existing distribution in stochastic process

Author's (Year)	**Distribution**	**Description**
G. Subash Chandra Bose et.al., (2012)[10]	Generalized Rayleigh distribution	Every organization needs a workforce suitable for its tasks in order to reach its business aims. In an organization wastages are seen when employees moving from one grade to another, are exposed to different factors influencing them to leave the organization. The threshold level is the maximum amount of wastage that can be permitted in the organization beyond which the organization reaches a point of breakdown. This paper is an attempt to determine the expected time for recruitment, assuming the threshold distribution as Generalized Rayleigh distribution.
Rajarathinam, A. and Manoharan, M. (2016)[25]	Lindly Distribution	The recruitment of persons in every organization is very important because the survival of the organization very much depends upon the availability of the manpower. The depletion of manpower in any organization may be due to the policy decisions taken by the management. To make up the loss of manpower, recruitments cannot be done after every decision making epoch. It is due to the fact that recruitment involves cost, time and manpower. So when the

		cumulative depletion of manpower due to successive decisions exceeds the threshold level, recruitment is necessary. The threshold level of manpower depletion which can be managed is assumed to be a random variable. In this paper, a stochastic model is developed to find the expected time recruitment under the assumption that the threshold level follows Lindly Distribution. Numerical illustrations are also provided.
P.Kondu Babu and S.Govinda Rao. (2017)[23].	Right truncated exponential distribution.	A manpower model is a statistical description of how change takes place in the organization. Manpower modelling is the prime concern for any management of human resources development. In studying the manpower system with Right Truncated Distributions, it is observed that the truncation parameter has vital role in the modelling of the manpower system. As this gives the value of the maximum length of service of an organization, the minimum value of such truncation parameter is very important to study the manpower planning models. As the most important factor for the management is to minimize the recruitment, in this study an attempt was made to optimize the truncated parameter for minimum strength of recruitment.
S.Vijaya and R.Jaikar (2019)[29]	Generalized logistic distribution	The category effect and promotion on grade structure of manpower organization is considered in this paper. Length of service has been calculated in each grade for promotion/upgrade in the organization. The time calculated for upgrade is done yearly once in the organization. A mathematical model through generalized logistic distribution is derived to reach a particular grade. Simulation study been carried out from this model.

TRANSMUTED LINDLEY DISTRIBUTION

In the fields of medical sciences, engineering and biological sciences, Lindley distribution has been widely used. It was introduced by Lindley (1958)[17]. A random variable X is said to have the Transmuted Lindley Distribution with parameter θ if its probability density is defined as

$$f(x,\theta) = \left(\frac{\theta^2}{1+\theta}\right)(1+x)e^{-\theta x}\left[1-\lambda+2\lambda\left[1+\left(\frac{\theta}{1+\theta}\right)\right]e^{-\theta x}\right] \quad x>0, \theta>0 \qquad \ldots(1)$$

The corresponding cumulative distribution function (c.d.f.) is:

$$F(x,\theta) = \left[1-\left(1+\frac{\theta x}{1+\theta}\right)e^{-\theta x}\right]\left[1+\left(\lambda+\frac{\theta\lambda x}{1+\theta}\right)e^{-\theta x}\right] \quad x>0, \theta>0 \qquad \ldots(2)$$

$$= 1+\left(\lambda+\frac{\theta\lambda x}{1+\theta}\right)e^{-\theta x}-\left(1+\frac{\theta x}{1+\theta}\right)e^{-\theta x}-\left(1+\frac{\theta x}{1+\theta}\right)\left(1+\frac{\theta x}{1+\theta}\right)\lambda e^{-\theta x}$$

$$= 1+\left(\lambda+\frac{\theta\lambda x}{1+\theta}\right)e^{-\theta x}-\left(1+\frac{\theta x}{1+\theta}\right)e^{-\theta x}\left(1+\frac{\theta x}{1+\theta}\right)^2\lambda e^{-\theta x}$$

$$= 1+\left(1+\frac{\theta x}{1+\theta}\right)\lambda e^{-\theta x}-\left[1+\left(\frac{\theta x}{1+\theta}\right)e^{-\theta x}\right]-\left(1+\frac{\theta x}{1+\theta}\right)^2\lambda e^{-\theta x}$$

$$F(x,\theta) = 1-\left[1+\left(\frac{\theta x}{1+\theta}\right)e^{-\theta x}\right]\left(\frac{\theta x}{1+\theta}\right)\left(1+\frac{\theta x}{1+\theta}\right)\lambda e^{-\theta x} \qquad \ldots(3)$$

The reliability function $R(x)$, which is the probability of an item not failing prior to sometime t, is defined by $R(x) = 1 - F(x)$. The reliability function of a transmuted Lindley distribution is given by

$$R(x,\theta) = \frac{\theta+1+\theta x}{\theta+1}e^{-\theta x}\left(1-\lambda+\lambda\frac{\theta+1+\theta x}{\theta+1}e^{-\theta x}\right) \qquad \ldots(4)$$

The hazard rate function for a transmuted Lindley random variable is given by

$$h(x,\theta) = \frac{\left(\frac{\theta^2}{1+\theta}\right)(1+x)e^{-\theta x}\left[1-\lambda+2\lambda\left[1+\left(\frac{\theta}{1+\theta}\right)\right]e^{-\theta x}\right]}{\left[1+\left(\frac{\theta x}{1+\theta}\right)e^{-\theta x}\right]\left(\frac{\theta x}{1+\theta}\right)\left(1+\frac{\theta x}{1+\theta}\right)\lambda e^{-\theta}} \quad \ldots(5)$$

DESCRIPTION OF STATISTICAL MODEL

$$\bar{H}\,(x) = 1 - F(x,\theta) = \left[1+\left(\frac{\theta x}{1+\theta}\right)e^{-\theta x}\right]\left(\frac{\theta x}{1+\theta}\right)\left(1+\frac{\theta x}{1+\theta}\right)\lambda e^{-\theta x}$$

$$= \left[1+\left(\frac{\theta x}{1+\theta}\right)e^{-\theta x}\right] + \left[\frac{\theta x}{1+\theta}+\left(\frac{\theta}{1+\theta}\right)^2 x^2\right]\lambda e^{-\theta x}$$

$$\bar{H}\,(x) = 1+\frac{\theta x}{1+\theta}\,e^{-\theta x}+\frac{\theta x}{1+\theta}\,\lambda\, e^{-\theta x}+\left(\frac{\theta}{1+\theta}\right)^2\lambda x^2 e^{-\theta x} \quad \ldots(6)$$

There may be no practical way to inspect an individual item to determine its threshold y. In this case the threshold must be a random variable. The shock survival probability is given by

$$P(X_i < Y) = \int_0^\infty g_k\,(x)\,\bar{H}\,(x)\,dx$$

$$= \int_0^\infty [g^*(\theta)]^k - \left(\frac{\theta x}{1+\theta}\right)\left[g^{*'}(\theta)\right]^k + \frac{\theta\lambda}{1+\theta}\left[g^{*'}(\theta)\right]^k + \left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2\left[g^{*''}(\theta)\right]^k \quad \ldots(7)$$

Equation denotes the k^{th} convolution

Therefore $\mathrm{S(t) = P[T > t]}$ is the survival function which gives the probability that the cumulative will fail only after time t.

$S(t) = P[T > t] =$ Probability that the total damage survives beyond t

$$P(T < t) = \sum_{k=0}^{\infty}[F_k(t) - F_{k+1}(t)]\,P(X_i < Y)$$

A renewal process is a counting process such that the time until the first event occurs has some distribution F, the time between the first and second event has, independently of the time of the first event, the same distribution F, and so on. When an event occurs we say that a renewal has taken place. It may happen that successive shocks become increasingly effective in causing damage, even though they are independent. This means that, the distribution function of the damage is

$$L(t) = 1 - [1 - g^*(\theta)] \sum_{i=1}^{\infty} F_k(t) [g^*(\theta)]^{k-1} - \left(\frac{\theta}{1+\theta}\right) + \left(\frac{\theta}{1+\theta}\right) \Big[1 - g^{*'}(\theta)\Big] \sum_{i=1}^{\infty} F_k(t) \left[g^{*'}(\theta)\right]^{k-1} + \left(\frac{\theta\lambda}{1+\theta}\right) - \left(\frac{\theta\lambda}{1+\theta}\right) \left[1 - g^{*'}(\theta)\right] \sum_{i=1}^{\infty} F_k(t) \left[g^{*'}(\theta)\right]^{k-1} + \left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2 - \left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2 \left[1 - g^{*''}(\theta)\right] \sum_{i=1}^{\infty} F_k(t) \left[g^{*''}(\theta)\right]^{k-1} \quad \ldots (8)$$

Taking Laplace transformation $L(t)$ we get,

$$L(t) = [1 - g^*(\theta)] \sum_{i=1}^{\infty} F_k(t) \, [g^*(\theta)]^{k-1} + \left(\frac{\theta}{1+\theta}\right) + \left(\frac{\theta}{1+\theta}\right) \left[1 - g^{*'}(\theta)\right] \sum_{i=1}^{\infty} F_k(t) \left[g^{*'}(\theta)\right]^{k-1} - \left(\frac{\theta\lambda}{1+\theta}\right) - \left(\frac{\theta\lambda}{1+\theta}\right) \left[1 - g^{*'}(\theta)\right] \sum_{i=1}^{\infty} F_k(t) \left[g^{*'}(\theta)\right]^{k-1} - \left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2 + \left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2 \left[1 - g^{*''}(\theta)\right] \sum_{i=1}^{\infty} F_k(t) \left[g^{*''}(\theta)\right]^{k-1} \quad \ldots (9)$$

By taking Laplace-Stieltjes transform, it can be shown that

$$L^{*}(t)=\frac{[1-g^{*}(\theta)]f^{*}(s)}{[1-g^{*}(\theta)f^{*}(s)]}-\left(\frac{\theta}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]f^{*}(s)}{[1-g^{*\prime}(\theta)f^{*}(s)]}+\left(\frac{\theta\lambda}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]f^{*}(s)}{[1-g^{*\prime}(\theta)f^{*}(s)]}$$

$$+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^{2}\frac{[1-g^{*\prime\prime}(\theta)]f^{*}(s)}{[1-g^{*\prime\prime}(\theta)f^{*}(s)]}$$

Let the random variable U denoting inter arrival time which follows exponential with parameter.

Now $f^{*}(s)=\left(\frac{c}{c+s}\right)$ substituting in the below equation we get

$$L^{*}(t)=\frac{[1-g^{*}(\theta)]\left(\frac{c}{c+s}\right)}{\left[1-g^{*}(\theta)\left(\frac{c}{c+s}\right)\right]}-\left(\frac{\theta}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]\left(\frac{c}{c+s}\right)}{\left[1-g^{*\prime}(\theta)\left(\frac{c}{c+s}\right)\right]}+\left(\frac{\theta\lambda}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]\left(\frac{c}{c+s}\right)}{\left[1-g^{*\prime}(\theta)\left(\frac{c}{c+s}\right)\right]}$$

$$+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^{2}\frac{[1-g^{*\prime\prime}(\theta)]\left(\frac{c}{c+s}\right)}{\left[1-g^{*\prime\prime}(\theta)\left(\frac{c}{c+s}\right)\right]}$$

$$=\frac{[1-g^{*}(\theta)]c}{c+s-g^{*}(\theta)\,c}-\left(\frac{\theta}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]c}{[c+s-g^{*\prime}(\theta)c]}+\left(\frac{\theta\lambda}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]c}{[c+s+g^{*\prime}(\theta)c]}$$

$$+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^{2}\frac{[1-g^{*\prime\prime}(\theta)]c}{[c+s+g^{*\prime\prime}(\theta)c]}$$

$$E(T)=\frac{d}{ds}\,L^{*}(s)$$

$$=\frac{[1-g^{*}(\theta)]c}{[c+s-g^{*}(\theta)\,c]^{2}}-\left(\frac{\theta}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]c}{[c+s-g^{*\prime}(\theta)c]^{2}}+\left(\frac{\theta\lambda}{1+\theta}\right)\frac{[1-g^{*\prime}(\theta)]c}{[c+s+g^{*\prime}(\theta)c]^{2}}$$

$$+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^{2}\frac{[1-g^{*\prime\prime}(\theta)]c}{[c+s+g^{*\prime\prime}(\theta)c]^{2}}$$

$$=\frac{1}{[1-g^{*}(\theta)]c}-\left(\frac{\theta}{1+\theta}\right)\frac{1}{[1-g^{*\prime}(\theta)]c}+\left(\frac{\theta\lambda}{1+\theta}\right)\frac{1}{[1-g^{*\prime}(\theta)]c}+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^{2}\frac{1}{[1-g^{*\prime\prime}(\theta)]c}$$

$$g^{*}(\theta)=\frac{\mu}{\mu+\theta}\quad,g^{*\prime(\theta)}=\frac{\mu}{(\mu+\theta)^{2}}\quad,\qquad g^{*\prime\prime(\theta)}=\frac{\mu}{(\mu+\theta)^{3}}$$

$$E(T) = \frac{1}{\left(1-\frac{\mu}{\mu+\theta}\right)c} - \left(\frac{\theta}{1+\theta}\right)\frac{1}{\left(1+\frac{\mu}{(\mu+\theta)^2}\right)c} + \left(\frac{\theta\lambda}{1+\theta}\right)\frac{1}{\left(1+\frac{\mu}{(\mu+\theta)^2}\right)c}$$

$$+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2 \frac{1}{\left(1+\frac{\mu}{(\mu+\theta)^3}\right)c}$$

On simplification we get the expected time is

$$E(T) = \frac{\mu+\theta}{\theta\, c} - \left(\frac{\theta}{1+\theta}\right)\frac{(\mu+\theta)^2}{[(\mu+\theta)^2+\mu]c} + \left(\frac{\theta\lambda}{1+\theta}\right)\frac{(\mu+\theta)^2}{[(\mu+\theta)^2+\mu]c}$$

$$+\left(\frac{\theta\sqrt{\lambda}}{1+\theta}\right)^2 \frac{(\mu+\theta)^3}{[(\mu+\theta)^3-\mu]c} \quad \dots (10)$$

NUMERICAL ILLUSTRATION

Simulation models are particularly useful in studying in small damaged machine where random fluctuations are likely to be more serious. The theory developed was tested using stimulated data in MathCAD software. To illustrate the method described in this paper, authors give some limited simulation results in the table 1 given.

Table 1. Predicting the parameters expected time in an organization when the inter-arrival time increases

c	$\mu = 0.3, \theta = 0.6, \lambda = 0.9$	$\mu = 0.6, \theta = 0.9, \lambda = 0.3$	$\mu = 0.9, \theta = 0.3, \lambda = 0.6$
1	1.688	1.486	4.009
2	0.844	0.743	2.005
3	0.563	0.496	1.336
4	0.422	0.372	1.002

5	0.338	0.297	0.802
10	0.169	0.149	0.400
20	0.084	0.074	0.200
30	0.056	0.049	0.134
40	0.042	0.037	0.100
50	0.034	0.029	0.080
100	0.017	0.015	0.040
200	0.008	0.007	0.020

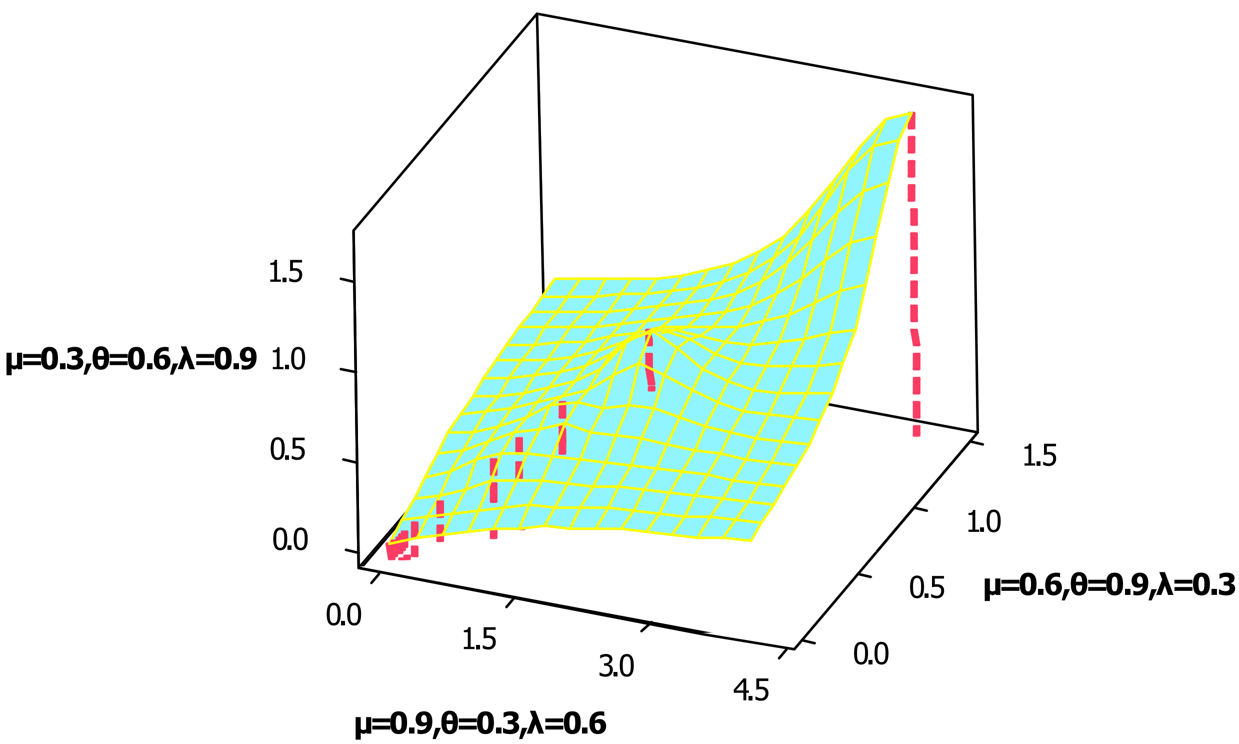

Figure 1. Predicting the parameters expected time in an organization

CONCLUSIONS

The statistical models have been discussed by various authors taking into consideration, many hypothetical assumptions. Such models provide the possible clues relating to the consequences of infections, the time taken for recruitment etc. Model obtained states that by setting c in the exponential distribution the average time will increase according to the increasing convolution function that depends on μ, θ, λ. The expected time observed that as the expected states in the inter arrival 'c' increases the parameter fix shows there is a decrease in the organization.

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