MANPOWER PLANNING MODEL USING TWO GRADES OF RECRUITMENT

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ABSTRACT

Most organizations need to pay more attention to long-term planning in order to function. Grading systems can show how successfully a company will do the task that has been assigned to it. The projected amount of time it will take to reach the threshold position, assuming that the ages between opinions are an arbitrary variable that is independently and identically distributed. Power Burr X distribution calculates the projected time to reach the threshold using the shock model. Numerical examples are provided to highlight interesting features of the model taken into consideration for the predicted time.

Key Words: Recruitment, Organization, Two Grade, Manpower Models and Power Burr X distribution.

INTRODUCTION

Planning for human resources is necessary in any organization to understand the many human resource features, such as recruiting, promoting, and letting go-also known as wastage-among others. A manpower model is a statistical explanation of how staff turnover occurs within a company. The manpower system needs manpower modelling through stochastic modelling because occurrences in the organization are unpredictable and uncertain. The fundamental basis for creating the manpower models is provided by stochastic modeling[14].

Managing huge organizations, such as governmental agencies, state and local governments, large corporations, or university institutions, requires effective manpower planning. These organizations have personnel of several classes, each with distinct duties and responsibilities. The process by which management decides how the company should transition from its existing manpower position to its target manpower position is known as manpower planning. Planning aims to maximize the long-term benefits for both the company and the individual by putting the right people in the right locations at the right times, doing the right activities[3]. Manpower planning is the collection of ideologies, instruments, and methods each organization should use to track and control the movement of employees both in terms of numbers and profiles. The internal changes in the current staff supply will affect how manpower is predicted[8].

However, in many organizations, notably with corporate and public sector, the recruitment is done in bulk depending on time. Srinivasa Rao and Govinda Rao (2014)[12] proposed manpower models with compound Poisson bulk recruitment in the initial grade. For the modelling to accurately estimate the manpower situations, the time-dependent character of recruitment must be introduced. This nature can be brought about by classifying the recruitment procedure as a non-homogeneous compound Poisson bulk process, in which the recruitment is carried out in modules of any size according to time. This model can be used to analyse manpower situations in settings like corporate offices that are more realistic.

The Burr Type X distribution, often known as the generalized Rayleigh distribution, is one of the twelve cumulative distribution functions that Burr (1942)[1] proposed. Numerous application fields, including lifespan testing, health, agriculture, biology, and other sciences, place a growing emphasis on this distribution. In this study, a two-grade personnel model with recruiting from two grades is developed and examined. Here, it is expected that the company has internal two grades, with the majority of hiring taking place in each of them in addition to promotions.

BACKGROUND OF TBHE STUDY

Manpower planning and control are intimately related to the expansion and development of a sector or an organization. The management of human resources in all corporate, private, and governmental organizations has recently placed a lot of focus on manpower planning models. The fundamental framework for an effective study and comprehension of manpower circumstances in any company is provided by manpower models[13]. Predicting the quantity of workers in each grade and their average tenure in the company is the fundamental goal of any manpower planning strategy. Any firm, especially one with skilled labor, should avoid having an excess or shortage of staff. The analysis of workforce situations has frequently employed mathematical models[9].

The responsibility for carrying out an organization's operations falls to people, who make up its manpower. An organization needs to use people as resources because they are complex and could be unpredictable. As a result, managing the personnel is exceedingly challenging. It is simpler to handle a good management that is impacted by a good organization. An organization is made up of a range of staff members with different ranks. Academic personnel may transition in a variety of ways from one status rank to another. It is challenging to follow and keep an eye on these motions. Every business or institution aspires to sustain staff members' involvement and output, particularly academic employees[5].

Table-1: Related existing distribution in stochastic process

Authors (Year)	Distribution	Description
P. Pandiyan et.al., (2012)[10]	Generalized Rayleigh Distribution	The estimated time to achieve the threshold level, based on the premise that the inter arrival time between decision epochs are i.i.d random variables, at the time of recruiting.
K. Kannadasan et.al., (2013)[6]	Three parameter generalized exponential distribution	An organization with two grades that experiences manpower decline as a result of its policy choices is taken into account. The loss of personnel is thought to be linear. Let X_i be a sequence of i.i.d random variables that represents the human resource loss caused by the ith decision period.
K. Parameswari and S. Venkatesh (2018)[7]	Extended exponential distribution	Considered is a two-graded organization where workforce depletion results from its operational choices. In order to generate an order statistics, the mathematical models are built assuming an exponential distribution for the loss of man hours and inter-decision times..
D. Samundeeswari. et.al., (2018)[4]	Exponential distribution	For a three-grade personnel system with attrition caused by its policy decisions, the time to recruitment is examined using a bivariate maximum policy of recruitment.

Ch. Ganapathi Swamy and K. Srinivasa Rao (2022)[2]	Poisson distribution	This paper's main focus is on the building and study of two graded manpower models with direct Duane recruiting processes in both grads. Time-dependent recruitments could be identified using Duane's hiring process. The Duane recruiting process employs Poisson and non-homogeneous Poisson processes as precise cases for given parameter values..

TWO GRADED MANPOWER MODEL

The goal of manpower needs models is to provide the human resource planner with information on how many of each type of worker is required to achieve a particular level of output. Any component that has been subjected to shocks and sustained damage is liable to fail when the cumulative damage reaches a certain threshold. Assuming that the criterion Y is met, power Burr X (PBX) distribution, as explained by[11].

$$F(t_1, t_2, \alpha_1, \alpha_2, \beta_1, \beta_2, \theta_1, \theta_2) = \left(1 - e^{\beta_1 {t_1}^{\theta_1}}\right)^{\alpha_1} \left(1 - e^{\beta_2 {t_2}^{\theta_2}}\right)^{\alpha_2}$$

$$= 1 - e^{-\left(\beta_2 {t_2}^{\theta_2}\right)^2} - e^{-\left(\beta_1 {t_1}^{\theta_1}\right)^2} + e^{-\left[\left(\beta_1 {t_1}^{\theta_1}\right)^2 + \left(\beta_2 {t_2}^{\theta_2}\right)^2\right]}$$

$$= 2\, \beta_1^2 \theta_1 t_1^{2\,\theta_1 - 1}\, e^{-\left(\beta_1 {t_1}^{\theta_1}\right)^2} + 2\beta_2^2 \theta_2 t_2^{2\,\theta_2 - 1}\, e^{-\left(\beta_2 {t_2}^{\theta_2}\right)^2}$$

$$- 4\theta_1\theta_2\beta_1^2\beta_2^2 t_1^{2\,\theta_1 - 1} t_2^{2\,\theta_2 - 1} \left[e^{-\left[\left(\beta_1 {t_1}^{\theta_1}\right)^2 + \left(\beta_2 {t_2}^{\theta_2}\right)^2\right]}\right] \quad \text{... (1)}$$

MODEL DESCRIPTION

In general, assuming that the threshold is Y

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

Now the threshold Y is such that it has two components namely Y_1 and Y_2 component. Transfer of component from Y_1 to Y_2 is also possible. We have the breakdown of the system is at $Y = max\,(Y_1, Y_2)$.

$$P\,[max\,(Y_1, Y_2)] = P[(Y_1 < y) \cap (\,Y_2 < y)] = P\,[(Y_1 < y)]\,P[(\,Y_2 < y)]$$

Now, Y_1 and Y_2 follows power Burr X distribution with parameter $\alpha_1, \alpha_2, \beta_1, \beta_2, \theta_1, \theta_2$.

$$P\left(\sum_{i=1}^{k} X_i < Y\right) = \int_0^\infty g_k(x)\left\{e^{-\left(\beta_2 t_2{}^{\theta_2}\right)^2} - e^{-\left(\beta_1 t_1{}^{\theta_1}\right)^2} + e^{-\left[\left(\beta_1 t_1{}^{\theta_1}\right)^2 + \left(\beta_2 t_2{}^{\theta_2}\right)^2\right]}\right\}dx \qquad \ldots(2)$$

$$= \int_0^\infty g_k(t)e^{-\left(\beta_2 t_2{}^{\theta_2}\right)^2}dt + \int_0^\infty g_k(t)\,e^{-\left(\beta_1 t_1{}^{\theta_1}\right)^2} - \int_0^\infty g_k(t_1, t_2)\,e^{-\left[\left(\beta_1 t_1{}^{\theta_1}\right)^2 + \left(\beta_2 t_2{}^{\theta_2}\right)^2\right]}dt_1 dt_2$$

$$= g_k^*\,(\beta_2^2 2\theta_2) + g_k^*\,(\beta_1^2 2\theta_1) - g_k^*\,(\beta_1^2 2\theta_1 + \beta_2^2 2\theta_2)$$

$$= [g^*\,(\beta_2^2 2\theta_2)]^k + [g^*\,(\beta_1^2 2\theta_1)]^k - [g^*\,(\beta_1^2 2\theta_1 + \beta_2^2 2\theta_2)]^k \qquad \ldots(3)$$

Survival analysis is a class of statistical models for studying the occurrence and timing of events. The survival function $S(t)$ which is the probability that an individual survives for a time t.

$$S(t) = P(T > t) = Probability\ that\ the\ total\ damage\ survives\ beyont\ t$$

$$= \sum_{k=0}^{\infty} P\{There\ are\ exactly\ k\ eopchs\ in\ (0, t] * P(the\ total\ cumulative\ (0, t]\}$$

$$S(t) = P(T > t) = \sum_{k=0}^{\infty} V_k(t) P\,[X_i < max\,(Y_1, Y_2)]$$

It may happen that successive shock become increasingly effective in causing damage, even though they are independent. This means that $V_k(t)$ the distribution function of the k^{th} damage is decreasing in $k = 1,2,3, \ldots$ foe each t. it is also known from renewal process that

$$P\{exactly\ k\ eopchs\ in\ (0,t]\} = F_k(t) - F_{k+1}(t)\ with\ \ F_0(t) = 1$$

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

$$= \sum_{k=0}^{\infty} [F_k(t) - F_{k+1}(t)][g^*\ (\beta_2^2 2\theta_2)]^k + [g^*\ (\beta_1^2 2\theta_1)]^k - [g^*\ (\beta_1^2 2\theta_1 + \beta_2^2 2\theta_2)]^k \quad \ldots (4)$$

Now, $L(T)\ =\ 1 - S(t)$

Taking Laplace transform of $L(T)$ we get,

$$L(T) =\ 1 - \left\{1 - g^*(\beta_1^2 2\theta_1) \sum_{k=1}^{\infty} [g^*(\beta_1^2 2\theta_1)]^{k-1}\right\} + \left\{1 - g^*(\beta_2^2 2\theta_2) \sum_{k=1}^{\infty} [g^*(\beta_2^2 2\theta_2)]^{k-1}\right\}$$

$$- \left\{[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2] \sum_{k=1}^{\infty} [g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2]^{k-1}\right\} \quad \ldots (5)$$

INTER ARRIVAL TIME USING EXPONENTIAL DISTRINUTION

Let the random variable U denoting inter arrival time which follows exponential with parameter c. Now $f^*(s) = \left(\frac{c}{c+s}\right)$ substituting in the above equation (5) we get,

$$l^*(s) = \frac{[1 - g^*(2\beta_1^2\theta_1)]\ f^*(s)}{[1 - g^*(2\beta_1^2\theta_1)\ f^*(s)]} + \frac{[1 - g^*(2\beta_2^2\theta_2)]\ f^*(s)}{[1 - g^*(2\beta_2^2\theta_2)\ f^*(s)]} - \frac{[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2)]\ f^*(s)}{[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2\ f^*(s)]}$$

$$= \frac{[1 -]\left(\frac{c}{c+s}\right)}{\left[1 - g^*(2\beta_1^2\theta_1)\left(\frac{c}{c+s}\right)\right]} + \frac{[1 - g^*(2\beta_2^2\theta_2)]\left(\frac{c}{c+s}\right)}{\left[1 - g^*(2\beta_2^2\theta_2)\left(\frac{c}{c+s}\right)\right]} - \frac{[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2)]\left(\frac{c}{c+s}\right)}{\left[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2\left(\frac{c}{c+s}\right)\right]}$$

$$= \frac{[1 - g^*(2\beta_1^2\theta_1)]\,c}{[c + s - g^*(2\beta_1^2\theta_1)c]} + \frac{[1 - g^*(2\beta_2^2\theta_2)]\,c}{[c + s - g^*(2\beta_2^2\theta_2)c]} - \frac{[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2)]\,c}{[c + s - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2)c]} \quad \ldots (6)$$

Now substituting the inter arrival time using exponential distribution we get,

$$g^*(2\beta_1^2\theta_1) = \frac{\mu}{\mu + 2\beta_1^2\theta_1}, \quad g^*(2\beta_2^2\theta_2) = \frac{\mu}{\mu + g^*(2\beta_2^2\theta_2)},$$

$$g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2) = \frac{\mu}{\mu + 2(\beta_1^2\theta_1 + \beta_1^2\theta_1)}$$

$$E(T) = -\frac{d}{ds} \;\; s = 0$$

$$E(T) = \frac{1}{[1 - g^*(2\beta_1^2\theta_1)]\,c} + \frac{1}{[1 - g^*(2\beta_2^2\theta_2)]\,c} - \frac{1}{[1 - g^*(2\beta_1^2\theta_1 + 2\beta_2^2\theta_2)]c}$$

On simplification we get the expected time as

$$E(T) = \frac{1}{c}\left[\frac{\mu + 2\beta_1^2\theta_1}{2\beta_1^2\theta_1} + \frac{\mu + 2\beta_2^2\theta_2}{2\beta_2^2\theta_2} - \frac{\mu + 2(\beta_1^2\theta_1 + \beta_2^2\theta_2)}{2(\beta_1^2\theta_1 + \beta_2^2\theta_2)}\right] \quad \ldots (7)$$

NUMERICAL ILLUSTRATION

A numerical example is used to discuss the model's behaviour. For the system's hiring, promotion, and exit rates, various values of the parameters are taken into account. Since the manpower model's performance characteristics are extremely time-sensitive, the transient behaviour of the model is investigated by constructing performance metrics using the following set of model parameter values.

RESULTS

The authors considered the two grades as β and θ, and by fixing the two grades the expected time for recruitment is been observed in table 1 and figure 1. The interval arrival time c is been estimated to increase $(c = 0.1, 0.2, 0.3, \dots, 1)$ and in three different situations $\mu = 0.5, 1, 1.5$, is been observed. The results found that as time increases the expected time to recruitment in an organization decreases in all the three levels.

Table 1. Expected time of two grades for recruitment in an organization

c	$\mu = 0.5$	$\mu = 1$	$\mu = 1.5$
0.1	19.271	19.542	19.813
0.2	9.132	9.264	9.396
0.3	5.752	5.838	5.924
0.4	4.063	4.125	4.188
0.5	3.049	3.097	3.146
0.6	2.373	2.412	2.451
0.7	1.89	1.923	1.955
0.8	1.528	1.556	1.583
0.9	1.246	1.27	1.294
1	1.021	1.042	1.063

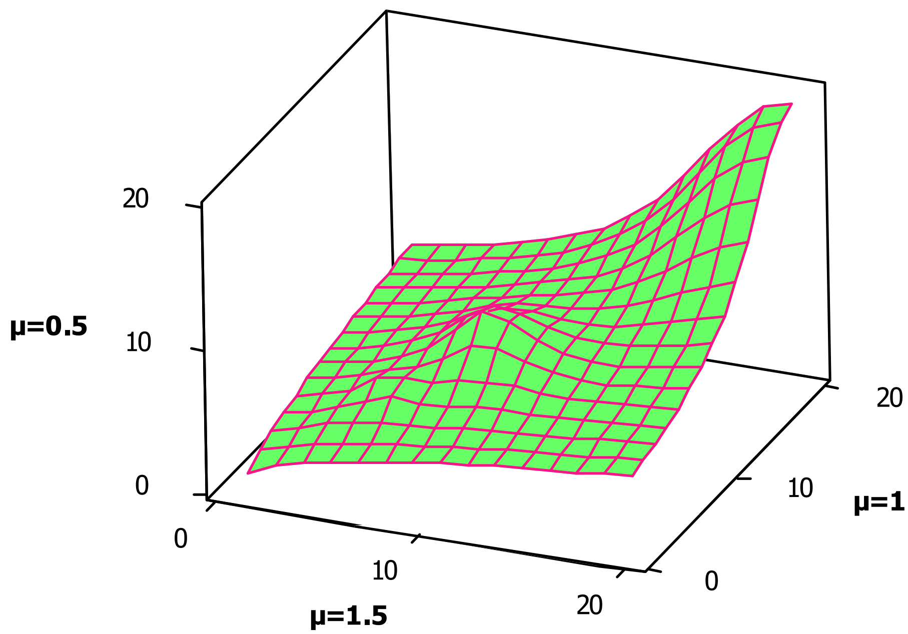

Figure 1. Expected time of two grades for recruitment in an organization

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