Significance of Manpower Planning for Expected Time to Recruitment Using Power Burr X Distribution

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Abstract

In an organization's human resource activity, manpower planning is critical. Every company's human resource is a valuable asset. Manpower planning primarily entails determining human resource needs and supply, as well as available resources. Manpower planning should be done in such a way that it meets the needs of both the business and the employer on a higher level. The model is used to calculate the expected time to hire. The analytical findings are supported by numerical examples.

Keywords: Manpower Planning, Expected time, Organization, Threshold and Power Burr X distribution.

INTRODUCTION

Each organization exists with the goal of reaching some sort of goal or objective. Firms use resources like manpower, money, machines, and materials to make this possible. A personnel planning is the first step in manpower management, and it consists of anticipating future worker demands, as well as anticipating worker availability, before comparing supply and demand. Inyang (2000)[2], first and foremost, personnel planning necessitates the identification of specific occupations created during the organizations structure. These individual jobs must be assessed in order to find the correct level of personnel to accomplish the given activities. The personnel department wasn't the only one who makes choices about staffing needs.

A manpower model is a statistical representation as to how examining changes in a company. A manpower function is a theoretical representation of where the organization changes. Manpower modeling is the most important consideration for any training & development administrator. For the identification and evaluation of the manpower network, stochastic modeling is required due to the unpredictability associated in the continuous process of manpower models. Various scholars have produced a wide range of personnel models to fit the needs of various businesses' manpower systems. In general, a company's personnel modeling can be divided into classes, which are mutually exclusive.The classes could be based on a grade, a wage level, an age group, or any other combination of classifications[12].

To a considerable extent, stochastic process models were used to conceptualize real-life problems as efficient numerical models. A technique like this allows for the creation of accurate and beneficial solutions. Manpower planning is a cross-functional task, it necessitates a combination of statisticians', economists', and behavioral scientists' technical skills, as well as managers' and planners' through practical understanding.

Any real-world scenario is frequently viewed as a statistical model, and so the major purpose of implementing a random process is that the optimal solution may be determined using traditional procedures. The benefit for such organization is attained with the design of appropriate strategies when stochastic models are employed in manpower planning. The key causes for wastage are the decrease of manpower in an organization includes policy changes concerning wages, targets, and perquisites. Due to the time and cost associated, frequent recruiting is not suggested. As a result, when the cumulative damage exceeds the threshold level, the wastage on frequent recruiting is permitted to accumulate.Personnel exits, also called as thresholds, are an important factor to consider in manpower planning[2].

Survival and reliability analysis is an important branch of statistics with fields such as engineering, economics, medical, actuarial science, and life testing, among other fields. In the statistical literature, different lifetime distributions have been established to allow better flexibility in modeling data within those applied disciplines. One of the most essential characteristics of generalized distributions is their ability to provide greater fit for a variety of life-time data found in applied disciplines. As a result, statisticians have been interested in developing novel distribution families to model similar data. The following are notable Burr distribution families; for data modeling, Burr (1942)[3] presented twelve different types of cumulative distribution functions. Burr-Type X and Burr-Type XII garnered the most attention out of the twelve distribution functions. Rodriguez (1977)[13] provides a thorough examination of Burr-Type XII distribution; for a more detailed description, see Wingo (1993)[14]. Because the Power Burr X distribution (PBX) model only has a decreasing hazard rate shape, it is only used to model data with an increasing failure rate. The PBX distribution is the proposed distribution in this article.

BACKGROUNDSUMMARY

Ashok Kumar. R and P. Gajivaradhan. (2018)[1]. In an organization's human resource strategy of manpower planning is crucial. Every company's human resource is a valuable asset. Manpower planning primarily entails determining human resource needs and supply, as well as available resources. Manpower planning must be done in a way that this really meets the needs of both the business and the employers on a greater level. The model yields the expected time and variation of time to recruiting. The analytical findings are supported by numerical examples.

Goparaju.A. et.al., (2019)[5].The application of stochastic modeling in an organization having various employee grades has been examined by a number of scholars. The goal of this study was to determine the goodness of fit of a three-parameter generalized Rayleigh distribution in various organizational grades. It focused on how long employees stayed in each grade and when they were anticipated to depart the company. The simulation work has been used to determine the model parameters of such a distribution. According to the findings of this study, the employee's length of stay increases as his or her grade rises.

Haposan Sirait. et.al., (2020)[6].Human resources are crucial in a company's commercial continuity, particularly for insurance businesses. In addition, an increase in the number of insurance clients is indeed a favorable impact for insurance businesses, and it must be balanced by company's human resources, which means that people must be recruited, but recruitment will indeed be time and cost sensitive. In this research, a statistical model is created to determine the estimated time for attaining a threshold level utilizing Lomax Distribution models. At the time of recruitment, independent and identically distributed (i.i.d) random variables for time between choice epochs been specified.

Manoharan. M and Rajarathinam. A (2021)[11].In stochastic process the shock model is being used to assess the threshold level, which is determined by the estimated time to recruitment in an organization using a shifted exponential distribution for the threshold level. Whenever the cumulative loss of man hour surpasses the threshold, recruitment occurs. The study's findings imply that the projected time to reach the organization's recruiting status, as well as its variance, are dependent on the various input components that are the distribution's characteristics.

Table - 1. Related existing distribution in stochastic process

Author's (Year)	**Distribution**	**Description**
M.Manoharan and Rajarathinam. A (2021)[10].	Generalized Exponentiated Gamma distribution.	To produce manufacturing operations in any firm, a variety of components are necessary, with manpower being the most important. Personnel requirements may change over time as a result of increased production activities or manpower depletion at random times. As a result, whenever the entire need for manpower exceeds the so-called threshold level, recruiting is required. The estimated time to recruiting was calculated on the premise that the threshold level is a random variable with a Generalized Exponentiated Gamma distribution.
K. Kannadasan. et.al., (2015)[9]	Three parameter generalized Pareto distribution	The estimated time to attain the organization's recruiting level is computed, and its variance is determined.
K.HariKumar, P.Sekar. (2014)[7]	Erlang distribution	The main premise is that as a random quantity of shortages accumulates as a result of subsequent attritions, the system will break down when the overall shortage reaches a random threshold level. The breakdown point, also known as the threshold, is the point at which immediate recruitment is required.
R. Elangovan and Ramani (2014)[4]	Two parameter type I Generalized	By assuming two parameter types, the estimated time to recruitment and its

	Logistic Distribution	variance been calculated throughshock model and cumulative damage process. The moment where the organization breaks down and surpasses the threshold value is also calculated.

POWER BURR X DISTRIBUTION

Let the random variable Y follows the Burr X distribution with parameters α and β. Then the power transformation $T = Y^{\frac{1}{\theta}}$ generates the PBX distribution. The random variable T follows the PBX distribution with parameters α, β and θ. The cumulative distribution function of PBX distribution is

$$F(t, \alpha, \beta, \theta) = \left(1 - e^{\left[-(\beta t^{\theta})^2\right]}\right)^{\alpha} \qquad for\ t > 0 \qquad \dots (1)$$

and corresponding probability density function is

$$f(t, \alpha, \beta, \theta) = 2\alpha\beta^2\theta t^{2\theta-1} e^{\left[-(\beta t^{\theta})^2\right]} \left(1 - e^{\left[-(\beta t^{\theta})^2\right]}\right)^{\alpha-1} \qquad \dots (2)$$

Where θ is an additional shape parameter, the survival rate function and the hazard rate function of PBX distribution are given respectively

$$S(t, \alpha, \beta, \theta) = 1 - F(t) = 1 - \left(1 - e^{\left[-(\beta t^{\theta})^2\right]}\right)^{\alpha} \qquad for\ t > 0 \qquad \dots (3)$$

$$h(t, \alpha, \beta, \theta) = \frac{2\alpha\beta^2\theta t^{2\theta-1} e^{\left[-(\beta t^{\theta})^2\right]} \left(1 - e^{\left[-(\beta t^{\theta})^2\right]}\right)^{\alpha-1}}{1 - \left(1 - e^{\left[-(\beta t^{\theta})^2\right]}\right)^{\alpha}} \qquad \dots (4)$$

MODEL DESCRIPTION AND SOLUTION

Esary et.al[8], proposed the Shock model and cumulative damage mechanism, which is outlined as;

i) Assume a unit or system which is subjected to shocks at random time intervals, causing a different degree of damage to the system.

ii) The system endures despite the cumulative damage caused by numerous shocks at random time intervals.

iii) Each device has a threshold level, which would be the system's durability capacity or the maximum permissible damage level.

iv) When the accumulated damage reaches a certain threshold, the system fails.

The survivor function is given by

$$S(t) = 1 - F(t, \beta, \theta) = e^{-(\beta t^{\theta})^2}$$

$$= e^{-\beta^2} t^{2\theta} \qquad \dots (5)$$

We investigate a system which is subject to shocks, with each shock reducing the system's effectiveness and increasing its operating costs. Consider the shocks happen at random, according to a PBX distribution. Using a value of α = 1 for the shape parameter

$$P(X_i < Y) = \int_0^\infty g_k(t)\, S(t)\, dt$$

$$= \int_0^\infty g_k(t) e^{-\beta^2} t^{2\theta}\, dt \qquad = g_k^*(\beta^2\ 2\theta)$$

$$= [g^*(\beta^2\ 2\theta)]^k \dots (6)$$

Probability that cumulative threshold would fail only after time *t* is given by the survival function.

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

$$= \sum_{k=0}^{\infty} \mathrm{P}\,\{\text{there are exactly k decisions in } (0,\mathrm{t}] * \mathrm{P}\ (\text{the total cumulative threshold } (0,\mathrm{t}]\}$$

It is also known from renewal process that

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

$$= \sum_{k=0}^{\infty} [F_k(t) - F_{k+1}(t)][g^*(\beta^2\ 2\theta)]^k \qquad \dots (7)$$

Now, the life time is given by

$P(T > t) = L\,(t) =$ The distribution function of life time (T)

Taking Laplace transformation $L(t)$we get

$$L(t) = 1 - [1 - g^*(\beta^2\ 2\theta)] \sum_{k=1}^{\infty} [g^*(\beta^2\ 2\theta)]^{k-1}$$

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

$$= 1 - [1 - g^*(\beta^2\ 2\theta)] \sum_{k=0}^{\infty} [F_k(t)][g^*(\beta^2\ 2\theta)]^{k-1} \qquad \text{... (8)}$$

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

$$l^*(s) = \frac{1 - g^*(\beta^2\ 2\theta) f^*(s)}{1 - g^*(2\beta^2\theta) f^*(s)} = \frac{1 - g^*(\beta^2\ 2\theta)\left(\frac{c}{c+s}\right)}{1 - g^*(2\beta^2\theta)\left(\frac{c}{c+s}\right)}$$

$$l^*(s) = \frac{[1 - g^*(\beta^2\ 2\theta)]c}{c + s - g^*(2\beta^2\theta)\ c} \qquad \text{... (9)}$$

$$g^*(2\beta^2\theta) = \frac{\mu}{\mu + 2\beta^2\theta}$$

The probability of an employee's expected time to leave the company is calculated.The mean time for the exit of an employee in an organization is found in equation (10).

$$E(T) = \frac{d}{ds} l^*(s)/s = 0 \quad = \frac{1}{1 - g^*(2\beta^2\theta)\ c} \quad = \frac{1}{\left[1 - \frac{\mu}{\mu + 2\beta^2\theta}\right] c}$$

$$E(T) = \frac{\mu + 2\beta^2\theta}{[\mu + 2\beta^2\theta - \mu]c} = \frac{\mu + 2\beta^2\theta}{2\beta^2\theta\ c} \ \text{... (10)}$$

NUMERICAL ILLUSTRATION

On the basis of the expressions derived for the expected time, the behaviour of the same due to the change in different parameters is shown in figures below.

Table - 2. The parametric representation at different level of expected time

C	$\boldsymbol{\beta = 0.1\ and\ \theta = 0.2}$			$\boldsymbol{\beta = 0.1\ and\ \mu = 0.5}$			$\boldsymbol{\mu = 0.5\ and\ \theta = 0.2}$		
	μ=0.5	**μ=1**	**μ=1.5**	**θ=0.3**	**θ=0.6**	**θ=0.9**	**β=0.2**	**β=0.3**	**β=0.4**
1	126	251	376	84.33	42.67	28.78	32.25	21.83	16.63
2	63	125.5	188	42.17	21.33	14.39	16.13	10.92	8.31
3	42	83.67	125.33	28.11	14.22	9.59	10.75	7.28	5.54

4	31.5	62.75	94	21.08	10.67	7.19	8.06	5.46	4.16
5	25.2	50.2	75.2	16.87	8.53	5.76	6.45	4.37	3.33
6	21	41.83	62.67	14.06	7.11	4.79	5.37	3.64	2.77
7	18	35.86	53.71	12.05	6.09	4.11	4.61	3.12	2.38
8	15.75	31.37	47	10.54	5.33	3.59	4.03	2.73	2.08
9	14	27.89	41.78	9.37	4.74	3.19	3.58	2.43	1.85
10	12.6	25.1	37.6	8.43	4.27	2.88	3.23	2.18	1.66
15	8.4	16.733	25.07	5.62	2.84	1.92	2.15	1.46	1.11
20	6.3	12.55	18.8	4.23	2.13	1.44	1.61	1.09	0.83
25	5.4	10.4	15.04	3.37	1.71	1.15	1.29	0.87	0.67

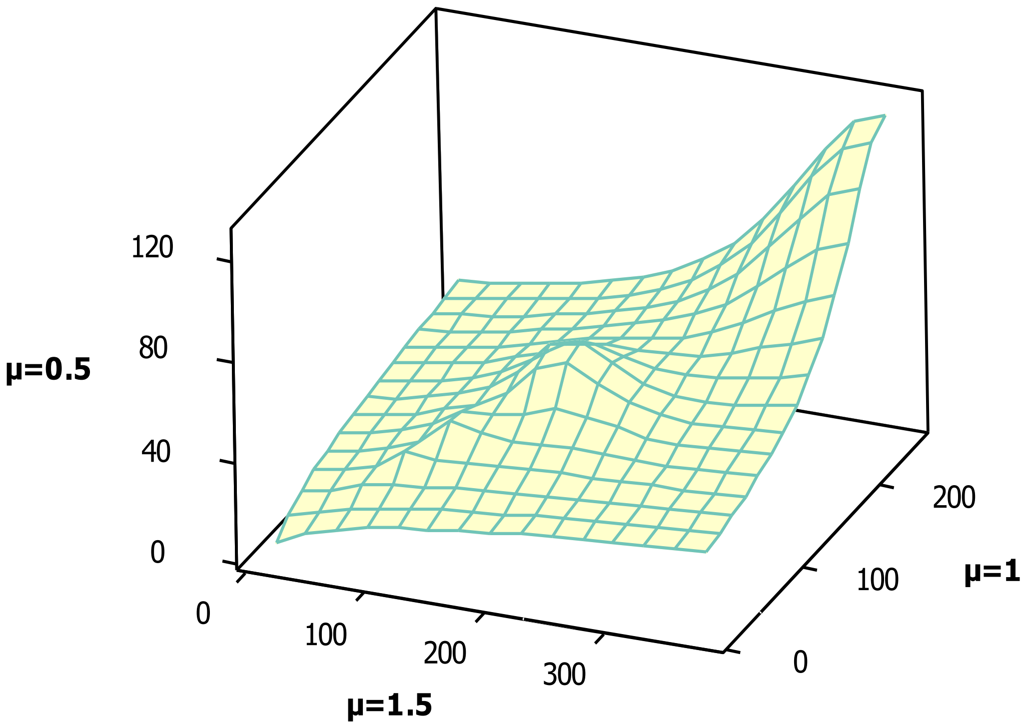

Figure - 1. Expected time of parameter μ increases at different level

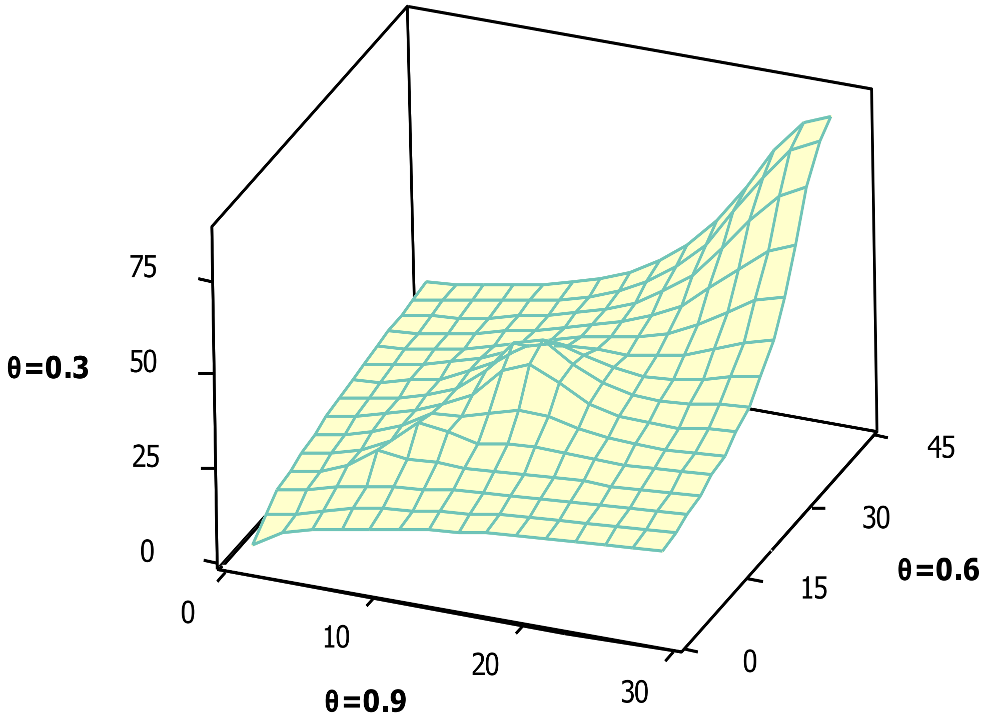

Figure - 2. Expected time of parameter θ increases at different level

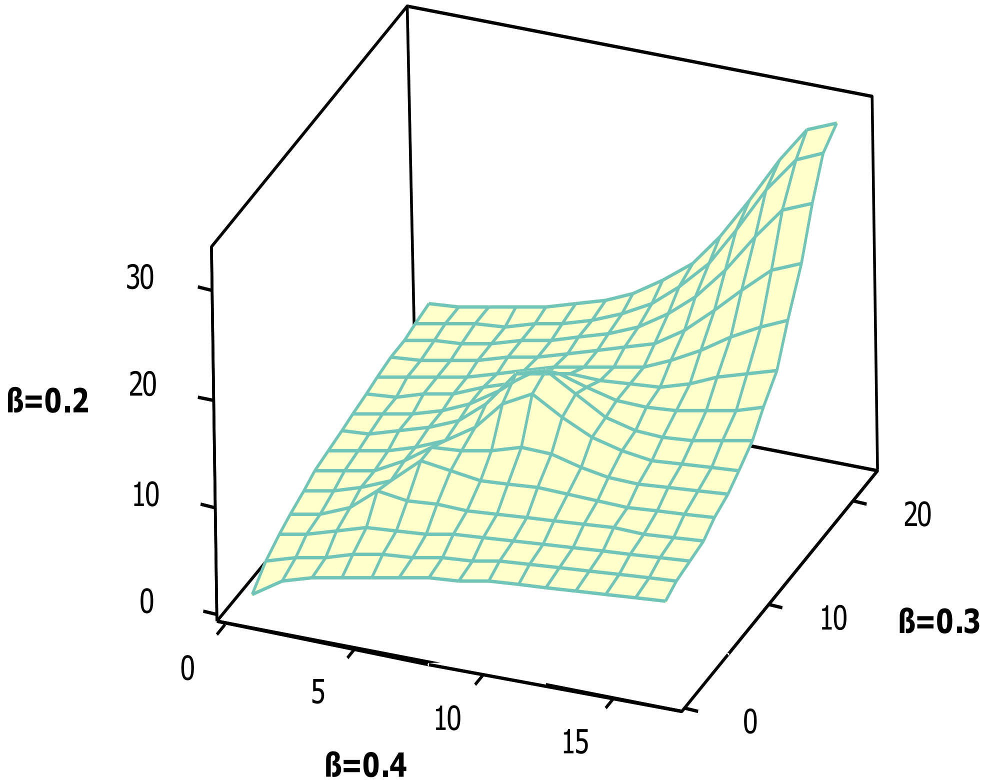

Figure - 3. Expected time of parameter β increases at different level

DISCUSSION

As the parameter $\beta = 0.1$ and $\theta = 0.2$ fixed, when *'c'* increases and also μ increases in different stage, i.e., $\mu = 0.5, 1, 1.5$.We observed that the expected time decreases in an organization at the initial stage very quickly when there is no recruitment done. Then as the inter-arrival time increases the expected time decreases gradually in the later stage.

For the parameter $\beta = 0.1$ and $\mu = 0.5$fixed, when *'c'* increases and also θ increases in different stage, i.e., $\theta = 0.3, 0.6, 0.9$ and for the parameter $\mu = 0.5$ and $\theta = 0.2$ fixed, when *'c'* increases and also β increases in different stage, i.e., $\theta = 0.2, 0.3, 0.4$, we found the same observation, i.e., as the expected time decreases in an organization at the initial stage very quickly when there is no recruitment done. Then as the inter-arrival time increases the expected time decreases gradually in the later stage as seen in Table 2 and Figure 1, 2 and 3.

CONCLUSION

In the present study, we have introduced a Power Burr X distribution. The three parameter Power Burr X distributionis embedded in the proposeddistribution. Some mathematical properties along with estimate the expected time are discussed.We believe thatthe subject distribution can be used in several different areas. We expect that this studywill serve as a reference and help to advance future research in the subject area.

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