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Mathematics

MANPOWER PLANNING MODEL FOR REGULAR AND TEMPORARY EMPLOYEE GRADES IN AN ORGAGNIZATION

Dr. S. Govinda Rao	Assistant Professor, ANGR Agricultural University, Agricultural College, Naira-532185, Srikakulam (Dist), Andhra Pradesh
C. Nageswara Rao	Lecturer in Mathematics, Rajah R S R K R R College, Bobbili- 535558, Vizianagaram (Dist), Andhra Pradesh

ABSTRACT   Manpower planning is a fundamental aspect of human research management in organizations. The objective of manpower planning is developing plans to meet the future human resource requirements. Manpower models create lot of interest due to the ready applicability in analyzing practical situations arising at places like, government and non-government organizations. The manpower models are highly influenced by three constituent processes namely, recruitment process, promotion process, and leaving processes. The resources of any organization comprise men, machine and material. In this paper, the manpower planning model for regular and temporary employee grades is studied. The model characteristics such as the joint probability generating function, the average number of employees in each grade, the mean duration of stay of an employee in each grade, the variance and co variance of the number of employees in each grade are analyzed.

KEYWORDS : Manpower planning model, recruitment process, average duration of stay and grade size distribution

1. INTRODUCTION

Manpower planning is a fundamental aspect of human research management in organizations. The objective of manpower planning is developing plans to meet the future human resource requirements. The resources of any organization comprise men, machine and material. Manpower planning is an important task of managing large organizations such as government, public sector, private sector and corporate.

The objective of the manpower planning is developing plans to meet the future human resource recruitment. A shortage as well as a surplus of employees would be highly undesirable. Statistical techniques have extensively been developed to support organizations in their manpower planning challenges.

Starting from the pioneering work by Seal (1945) a large number of manpower models have been developed and analyzed with various assumptions in order to analyze the practical situations. A good review of manpower models is given by Wang (2005). Bartholomew has utilized the probability distributions for developing the manpower models using complete length of service of an employee. F.I.Ugwuowo and S.I. Mc. clean (2000) have reviewed the heterogeneity in manpower models.

An employee, who recruited in the temporary grade may be promoted to the regular grade or leave the organization after spending a random duration of time in that grade. The employee in the regular grade may leave the organization after a random period of time.

2. MANPOWER PLANNING MODEL FOR REGULAR AND TEMPORARY EMLOYEES IN AN ORGANIZATION

In this section, we assume that recruitment process of temporary employee follows a Poisson process with parameter λ_1. The recruitment process of the regular employee also follows a Poisson process with parameter λ_2. The promotion process from temporary to regular also follows a Poisson process with parameter λ_1. The leaving process of temporary and regular employee is also Poisson with parameters α and μ_2 respectively. The schematic diagram representing manpower model in the organization is given in fig: 1
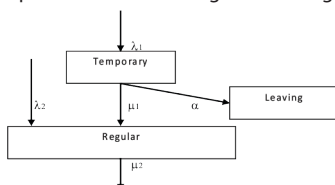

Fig. 1: The schematic diagram of the model.

Let $P_{n,m}(t)$ be denote the probability that there are 'n' temporary employees and 'm' regular employees at time 't' in the organization.

Then the joint probability generating function of the model as

$$P(Z_1, Z_2; t) = c.\exp\left\{\frac{\lambda_1 b e^{(\alpha+\mu_1)t}}{\alpha+\mu_1} + \frac{a e^{\mu_2 t}}{\mu_2}\left[\lambda_2 - \frac{\lambda_1\mu_1}{\mu_2-\alpha-\mu_1}\right]\right\} \quad X.Y, \quad |Z_1|<1; |Z_2|<1$$

where,

$$X = \left[1-(1-Z_1)e^{-\mu_1 t} - \left(\frac{\mu_1}{\mu_1-\mu_2}\right)(1-Z_2)(e^{-\mu_1 t}-e^{-\mu_2 t})\right]^{N_0}$$

$$Y = \left[1-(1-Z_2)e^{-\mu_2 t}\right]^{M_0}$$

3. CHARACTERISTICS OF THE MODEL

In this section, the joint probability generating function of the number of employees in the temporary and regular grades is obtained as

The mean number of temporary employees in the organization is

$$L_1 = \frac{\lambda_1}{\alpha+\mu_1}\left(1-e^{-(\alpha+\mu_1)t}\right) + N_0 e^{-\mu_1 t}$$

The mean number regular employees in the organization is

$$L_2 = \frac{\lambda_1\mu_1\left(1-e^{-(\alpha+\mu_1)t}\right)}{(\alpha+\mu_1)(\mu_2-\alpha-\mu_1)} + \left(\lambda_2-\frac{\lambda_1\mu_1}{\mu_2-\alpha-\mu_1}\right)\left(\frac{1-e^{\mu_2 t}}{\mu_2}\right) + \left[\frac{N_0\mu_1}{\mu_1-\mu_2}\left(e^{-\mu_1 t}-e^{-\mu_2 t}\right)\right]^{N_0} + M_0 e^{-\mu_2 t}$$

The mean number of employees in the organization is
L=L₁+ L₂

The average duration of stay of an employee in the temporary grade in the organization is

$$W_1 = \frac{L_1}{(\alpha+\mu_1)(1-P_{0..}(t))}$$

The average duration of stay of a regular employee in the organization is

$$W_2 = \frac{L_2}{\mu_2(1-P_{.0}(t))}$$

The variance of the number of temporary employees in the organization is

$$V_1 = \frac{\lambda_1}{\alpha+\mu_1}\left(1-e^{-(\alpha+\mu_1)t}\right) + N_0 e^{-\mu_1 t}$$

The variance of the number of regular employees in the organization is

$$V_2 = \frac{\lambda_1 \mu_1 \left(1 - e^{-(\alpha + \mu_1)t}\right)}{(\alpha + \mu)(\mu_2 - \alpha - \mu_1)} + \left(\lambda_2 - \frac{\lambda_1 \mu_1}{\mu_2 - \alpha - \mu_1}\right)\left(\frac{1 - e^{\mu_2 t}}{\mu_2}\right) + \left[\frac{N_0 \mu_1}{\mu_1 - \mu_2}\left(e^{-\mu_1 t} - e^{-\mu_2 t}\right)\right]^{N_0} M_0 e^{-\mu_2 t}$$

The coefficient of variation of the number of temporary employees in the organization is

$$CV_1 = \frac{\sqrt{V_1}}{L_1}$$

The coefficient of variation of the number of regular employees in the organization is

$$CV_2 = \frac{\sqrt{V_2}}{L_2}$$

4. NUMERICAL ILLUSTRATIONS AND APPLICATION

The behavior of the proposed model is discussed through a numerical illustration. The average number of employees in the regular and temporary grade are computed and presented in table 1

It is observed that the average number of employees in the regular and temporary grades in the organization is highly sensitive with respect to changes in time. As time't' varies for different units, the average number of employees in the temporary grade reduced, when other parameters are fixed. Similarly, the average number of employees in the regular grade in the organization reduced for given values of the other parameters. The decrease in the average number of employees in temporary grade is more rapid, when compared to that of regular employees.

The leaving rate of temporary staff (α) in the organization is also studied. As the leaving rate of temporary staff (α) varies for different units, the average number of

temporary grade is moderate, when compared to that of regular grade. As the recruitment rate of temporary staff ($_1$) varies for different units, the average number of employees in the temporary grade is increased when other parameters are fixed. The increase in average number of temporary employees is moderate, when compared to that of regular employees.

As the recruitment rate of temporary staff ($_1$) varies for different units, the average number of employees in the temporary grade is increased when other parameters are fixed. The increase in average number of temporary employees is moderate, when compared to that of regular employees.

When the promotion rate from temporary to regular grade ($_2$) varies for different units, the average number of employees in the temporary grade remains unchanged, when other parameters are fixed. There is no change in average number of temporary employees, when compared to that of regular employees.

When the recruitment rate of the regular staff ($_1$) varies for different units, the average number of employees in the temporary grade is decreased when other parameters are fixed at. Similarly, the decrease in average number of temporary employees is more rapid, when compared to that of regular employees.

When the leaving rate of regular grade ($_2$) varies for different units, the average number of employees in the temporary grade remains unchanged, when other parameters are fixed. The average number of employees in the regular grade in the organization is decreasing for given values of other parameters.

The average duration of stay of an employee in the temporary and regular grades in the organization at different time points are computed and presented in table 2.

It is observed that the average duration of stay of an employee in the regular and temporary grade in the organization are highly sensitive with respect to changes in time. As time (t) varies for various units, the average duration of stay of an employee in the temporary grade reduced when other parameters are fixed. Similarly, the average duration of stay of an employee in the regular grade in the organization reduced. The decrease in the average duration of stay of an employee in temporary grade is moderate, when compared to that of a regular employee.

The effect of leaving rate of temporary staff () on the duration of stay of an employee in the organization is also studied. As the leaving rate of temporary staff () varies for various units, the average duration of stay of an employee in the temporary grade decreased when other parameters are fixed. Similarly, the average duration of stay of an employee in the regular grade in the organization increased. The decrease in average duration of stay of an employee in temporary grade is moderate, when compared to that of regular grade.

As the recruitment rate of temporary staff ($_1$) varies for various units, the average duration of stay of an employee in the temporary grade is increased, when other parameters are fixed. The average duration of stay of an employee in the regular grade in

Table 1 The values of L$_1$, L$_2$ for different values of parameters

T		$_1$	$_2$	$_1$	$_2$	L$_1$	L$_2$
0.1	2	2	3	4	5	335.31	188.496
0.5	2	2	3	4	5	67.984	115.462
0.75	2	2	3	4	5	25.223	55.72
1	2	2	3	4	5	9.49	24.684
2	2	2	3	4	5	0.501	1.451
3	2	2	3	4	5	0.336	0.878
1	**3**	2	3	4	5	9.443	24.649
1	**4**	2	3	4	5	9.408	24.622
1	**5**	2	3	4	5	9.38	24.6
1	2	**1**	3	4	5	9.324	24.555
1	2	**3**	3	4	5	9.657	24.814
1	2	**5**	3	4	5	9.989	25.073
1	2	2	**1**	4	5	9.49	24.287
1	2	2	**4**	4	5	9.49	24.883
1	2	2	**5**	4	5	9.49	25.082
1	2	3	3	**6**	5	1.48	14.342
1	2	3	3	**7**	5	0.678	11.772
1	2	3	3	**8**	5	0.368	10.122
1	2	3	3	4	**7**	9.657	12.404
1	2	3	3	4	**9**	9.657	7.843
1	2	3	3	4	**11**	9.657	5.683
1	2	3	3	4	11	2.33	1.501
1	2	3	3	4	11	5.993	3.592
1	2	3	3	4	11	13.32	7.775
1	2	3	3	4	11	13.32	7.778
1	2	3	3	4	11	13.32	7.781
1	2	3	3	4	11	13.32	7.785

employees in the temporary grade reduces when other parameters are fixed. Similarly, the decrease in average number of employees in

Table 2 The values of w$_1$, w$_2$ for different values of parameters

T		$_1$	$_2$	$_1$	$_2$	W$_1$	W$_2$
2	2	2	3	4	5	0.084	0.758
3	2	2	3	4	5	0.056	0.305
4	2	2	3	4	5	0.056	0.299
2	**3**	2	3	4	5	0.056	0.764
2	**4**	2	3	4	5	0.052	0.77
2	**5**	2	3	4	5	0.043	0.775
2	2	**1**	3	4	5	0.056	0.786
2	2	**3**	3	4	5	0.112	0.742
2	2	**5**	3	4	5	0.167	0.731

2	2	2	**1**	4	5	0.084	0.919
2	2	2	**4**	4	5	0.084	0.737
2	2	2	**5**	4	5	0.084	0.731
2	2	2	3	**6**	5	0.032	0.372
2	2	2	3	**7**	5	0.025	0.35
2	2	2	3	**8**	5	0.02	0.341
2	2	2	3	4	**7**	0.084	0.308
2	2	2	3	4	**9**	0.084	0.199
2	2	2	3	4	**11**	0.084	0.148
2	2	2	3	4	5	0.061	0.368
2	2	2	3	4	5	0.072	0.535
2	2	2	3	4	5	0.084	0.758
2	2	2	3	4	5	0.095	1.072
2	2		3	4	5	0.095	1.086
2	2	2	3	4	5	0.095	1.1

As the recruitment rate of temporary employees ($_1$) varies for different units, the variance of the number of employees in the temporary grade is increased, when other parameters are fixed. The variance of the number of employees in the regular grade in the organization increased for given values of the other parameters. The increase in variance of the number of temporary employees is moderate, when compared to that of regular

Table.3 The values of V_1, V_2, CV_1 and CV_2 for different values of parameters

T		$_1$	$_2$	$_1$	$_2$	V_1	V_2	CV_1	CV_2
1	2	2	3	4	5	9.49	24.684	0.325	0.201
2	2	2	3	4	5	0.501	1.451	1.413	0.83
3	2	2	3	4	5	0.336	0.878	1.724	1.067
1	**3**	2	3	4	5	9.443	24.649	0.325	0.201
1	**4**	2	3	4	5	9.408	24.622	0.326	0.202
1	**5**	2	3	4	5	9.38	24.6	0.327	0.202
1	2	**1**	3	4	5	9.324	24.555	0.327	0.202
1	2	**3**	3	4	5	9.657	24.814	0.322	0.201
1	2	**5**	3	4	5	9.989	25.073	0.316	0.2
1	2	2	**1**	4	5	9.49	24.278	0.325	0.203
1	2	2	**4**	4	5	9.49	24.883	0.325	0.2
1	2	2	**5**	4	5	9.49	25.082	0.325	0.2
1	2	3	3	**6**	5	1.48	14.342	0.819	0.264
1	2	3	3	**7**	5	0.678	11.772	1.214	0.291
1	2	3	3	**8**	5	0.368	10.122	1.649	0.314
1	2	3	3	4	**7**	9.49	12.31	0.325	0.285
1	2	3	3	4	**9**	9.49	7.77	0.325	0.359
1	2	3	3	4	**11**	9.49	5.623	0.325	0.422
1	2	3	3	6	5	2.33	1.501	0.655	0.816
1	2	3	3	7	5	5.993	3.592	0.408	0.528
1	2	3	3	8	5	13.32	7.775	0.274	0.359
1	2	3	3	4	7	13.32	7.778	0.274	0.359
1	2	3	3	4	9	13.32	7.781	0.274	0.358
1	2	3	3	4	11	13.32	7.785	0.274	0.358

the organization decreased for given values of the other parameters. The increase in average duration of stay of a temporary employee is moderate, when compared to that of a regular employee.

When the promotion rate from temporary to regular grade ($_2$) varies for various units, the average duration of stay of an employee in the temporary grade remains unchanged, when other parameters are fixed. The average duration of stay of an employee in the regular grade in the organization decreased for given values of the other parameters. There is no change in the average duration of stay of a temporary employee, when compared to that of a regular employee.

When the recruitment rate of the regular employee ($_1$) varies for various units, the average duration of stay of an employee in the temporary grade is decreased when other parameters are fixed. Similarly, the average duration of stay of an employee in the regular grade in the organization is decreased for given values of the other parameters. The decrease in average duration of stay of temporary employees is less, when compared to that of a regular employee.

When the leaving rate of a regular employee ($_2$) varies for various units, the average duration of stay of an employee in the temporary grade remains unchanged when other parameters are fixed. The average duration of stay of an employee in the regular grade in the organization is decreased for given values of the other parameters. There is no change in the average duration of stay of a temporary employee is moderate, when compared to that of a regular employee.

The variance of the number of employees in the temporary and regular grades in the organization at different time points are computed and presented in table 3. It is observed that the variance of the number of employees in the regular grade and temporary grade in the organization are highly sensitive with respect to changes in time. As time (t) varies for different units, the variance of the number of employees in the temporary grade reduced when other parameters are fixed. Similarly, the variance of the number of employees in the regular grade in the organization reduced for given values of the other parameters. The decrease in the variance of the number of employees in temporary grade is more rapid, when compared to that of regular employees.

The effect of leaving rate of temporary staff () on the variances of the number of employees in the organization is also studied. As the leaving rate of temporary employees () varies for different units, the variances of the number of employees in the temporary grade reduced, when other parameters are fixed. Similarly, the variance of the number of employees in the regular grade in the organization reduced for given values of the other parameters. The decrease in variance of the number of employees in temporary grade is moderate, when compared to that of regular employees

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When the leaving rate of regular employees ($_2$) varies, the variance of the number of employees in the temporary grade remains unchanged, when other parameters are fixed. The variance of the number of employees in the regular grade in the organization is decreased for given values of other parameters. There is no change in variance of the number of temporary employees, when compared to that of regular employees.

5. SUMMARY AND CONCLUSIONS

The bivariate manpower model for temporary and regular staff is analyzed with heterogeneous recruitment rates. The transient behavior of the model is analyzed by deriving the system characteristics like, the average number of employees in temporary grade, the average number of employees in regular grade, the average duration of stay of an employee in temporary grade, the

average duration of stay of an employee in regular grade, the variance of number of employees in temporary grade, the variance of number of employees in regular grade etc., are derived and analyzed. The sensitivity of the model with respect to the recruitment rates, promotion rate, leaving rate is also analyzed through numerical illustrations.

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