A COMPREHENSIVE REVIEW ON CONTRIBUTIONS TO THE STUDY OF STOCHASTIC MODELS IN MANPOWER PLANNING

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Abstract: We took for the following results stochastic analysis of business with two levels and manpower with three levels in man power planning.

Keywords: Stochastic models, Queuing theory, Man power planning.

I Introduction

In any country the socio economic welfare of the people is the matter of prime concern and interest. The people as well as those at the governance strive hard to achieve the economic and social prosperity. However the economic welfare is a causative factor of social prosperity. To a large extent depends upon the natural resources available in that country. But the availability of the natural resources is not alone enough. A well planned utilization of the same is very important. Natural resources no doubt includes manpower as well that optimal utilization of the same leads to prosperity and economic development of the country. So just as planning required for exploitation and utility of all natural resources, effective planning is required for utilization of manpower. This fact being strongly considered by the government of India that they have created a separate portfolio in the name of HUMAN RESOURCES DEVELOPMENT. It is appropriate to quote the observations of Grinold. R.C and K.T. Marshall "Manpower planning must be an ancient art, since manpower problems have existed for centuries".

Waker. J.W. has rightly pointed out the need and importance of manpower planning and utilization by stating that "Manpower planning refers to the rather complex task of forecasting and planning for the right number and the right kind of people at the right places at the right time to perform activities that will benefit both the organization and the individual in it".

According to Grinold and Marshall, "There is interaction between the four ingredients of a manpower namely people, job, time and money. The growth of an organization depends on better management of money, time, job and the manpower. Bennsion and Casson stated that 'organizations have become more complex requiring a wider range of specialist'. A wider range of specialists mean persons who have specialized in a particular field, persons who have developed a special skill like operating special machineries, manufacturing skill, marketing skill, etc. Any organization or a manufacturing company will have to recruit such skilled persons for its growth, so, if they quit it will be very difficult to replace or find substitute. More dangerous is that the client may go behind them or that good will of the company is likely to be lost. There are very many causes for a business concern to get in to crises, may be because of non availability of a particular raw material or power shortage or sudden competition coming up in the market because of innovative marketing strategy or sudden competition coming up in the market because of innovative marketing strategy or government policies or natural calamities or war between countries. But certain causes are extraordinary, normal and most common are shortage of money and manpower. Human Resource is vital department in any company, sensitive and to be handled by experts only. The failure to provide appropriate type of personnel and manpower result in business getting in to crisis state. Therefore an overall need arises for improved and sophisticated manpower

management. Manpower shortage will lead to recruitment process resulting in huge expenditure. The various costs associated with the policy making in manpower management is indicated in Poornachandra Rao.

A greater emphasis was laid on manpower planning in twentieth century, particularly after a boom in Information Technology throughout the world. Rapid growth in information technology created a high demand for software are hardware engineers. Industries to individuals all use computers for its multifarious purpose that the demand for computer and its accessories have gone up, so naturally manpower is required for such industries. There is growing competition in business and quality products find a high demand with the public. So many industries and manufacturing units have come up, resulting in high demand for both skilled and non skilled labourers. More private sectors come up because of the encouragement and assistance given by the government and for their participation in nation's development. This opened new and fast employment opportunities to educated, skilled and unskilled people. In the field of medical service also the need for highly skilled professional is very much on the increase nowadays. Hence the need of proper planning of manpower resources and proper utilization of the same has resulted in the emergence of manpower planning as a separate division of management science, and Human Resources Management (HRM) is considered to be a sensitive area of study and approach.

II Background of Manpower Planning

In the early 1970s many companies were planning significant expansion. During this period such companies were quick to realize that the key to success was an adequate supply of appropriately skilled people. This led to the emergence of human resource planning as a personal management tool. Manpower planning is the process of ensuring that the optimal number of human resource is available at the right time and at right place. Companies use analytic and rationale methods to forecast their human resource requirements for which they need appropriate analytical tools. Much effort was devoted to developing tools and techniques to assist managers in their planning. Many of these were based on the theory of Stochastic processes and more specifically on the concept of Markov chains, Bowey.

In large organizations the flow of individuals between the various ranks is a task which requires careful and detailed monitoring. A close and a careful study has to be made in the individual's joining, staying and quitting the concern over a period of time by the managers Such serious study would give a clear picture the time to shortage, the time of recruitment. In a stable environment where the features and characteristics of product and labor markets are expected to evolve in a predictable and orderly fashion, a model of long term organization would emerge. This would show the expected number of retirements, the expected turnover of staff, within departments and for involuntary reasons. This can give a broad and rather basic picture of staff turnover. Hence it can also be used to provide valuable information on timings and rates for replenishing staff. To maintain stable level of employees over time management requires data on where, when and how many employees need to be recruited.

III Approach to Manpower Planning

The simplest and oldest approach to manpower planning is perhaps the so called replacement table method; a list of men or groups of men presently in the systems organized by function and job level, provides a description of the current inventory. The main problem, according to this approach is to ensure that as men quit, retire, or die suitable candidates will be ready to move into their jobs. Retirement statistics can be predicted with precision and coupled with historical information, general actuarial data, an estimate about the future loss can be estimated. Thus rough estimates can be made of where and when vacancies will occur.

The replacement table method is laborious to carry through by hand computations, and it usually reflects a static rather than a dynamic picture of an organization's structure and needs. The development of other approaches have come since world war II in response to variety of particular problems.

IV Classification of Manpower Models

A computer model can basically be classified into two distinct categories. In the first category, the flow rate of one grade of manpower professionals into the same, higher or even lower grades over a fixed period of time is given. This generates ultimately fixed proportions of manpower in different grades. These types of models are known as Markovian models or models based on Markov chains. In second category, given the distribution of the grade sizes, the flow rates from one category of manpower to other is obtained on the basis of the given grade structure or probability vector of different grades. These kinds of models are known as Renewal models.

Concept of Manpower Planning

Process by which Management determines how the management should move from its current manpower to its desired manpower utilization described a formal planning is based on the following:

- Establishment and recognition of future job requirement.
- Scanning the organization through systematic manpower audit.
- Assured supplies of qualified participants.
- Development of available manpower.
- Effective utilization of current and prospective workforce members.

V Steps in Manpower Planning

- Predict strategies for manpower plans.
- Design job description and the job requirements.
- Find adequate sources of recruitment.
- Give boost to youngsters by appointment to higher posts.
- Best motivation for internal promotion.
- Closely observe the expected losses due to retirement, transfer and other issues.
- See for replacement due to accident, death, dismissals and promotion.

VI Need and Importance of Manpower Planning

The main factors which determine the behavior of a manpower system are:

(i) Recruitment
(ii) Promotion of employees
(iii) Wastage

(i). Recruitment

The sizes of various grades, which respond in the expansion, promotions and wastages, are maintained at the desired level at any time by a process of recruitment. The recruitment can be made in several ways. Vacancies can be filled as and when they arise or they may be allowed to accumulate and then filled up at specified periods. The recruitment can be made by the organization itself or by some external agencies to avoid delay and huge overhead cost.

The concept of recruitment also plays an important role in planning. Retirement is a part of flow. The number of recruits in each category is represented as a recruitment vector. In dealing with the problems of maintaining a given structure of an organization recruitment control plays an important role and it is done by the proper choice of the retirement vector r and p, where r is the number of recruits in each category and p is the transition probability matrix describing the transitions of individuals between the grades of that organization.

(ii). Promotion of Employees

Normally vacancies that arise in the lower grade are filled up by recruitment whereas those in the higher are filled up by promotions. Some of the promotion rules are:

a) The Senior most in the grade is promoted.
b) Promotion is given at random.
c) Those that fill certain efficiency criterion along with some minimum completed length of service are promoted.

As per the rule (a), the length of service is the sole criterion for promotion and hence the management can control it. The rule (b), gives full freedom to the management to promote any employee of their choice, which also is not desirable. Normally rule (c) is preferred. Some of the reasons, which influence the promotion policies are (i) pressure, (ii) efficiency and (iii) length of service.

Promotion denotes that an individual has the competencies, i.e. the skills, knowledge and attitude required to perform effectively at the next higher rank. The competencies reflect the knowledge and skills exhibited in observable behavior in the relevant areas of work. Promotion provides motivation with additional salary, responsibility and authority to perform well and is an important part of performance management.

(iii). Wastage

Wastage in manpower planning terminology refers to the leaving process of persons from an organization. It is the most fundamental concept that plays a key role in manpower planning. In fact wastage has impact upon the manpower system. Wastage arises due to individual decisions to leave the organization and is hence outside the direct control of the management. In organizations where the number of jobs is controlled, it is wastage which creates vacancy and so provides opportunity for promotion and recruitments. Hence the measurement of wastage is very important for the successful formulation of manpower policies, Statistical analysis of data on wastage is found to be very useful for making policy decisions. The term wastage is also used to refer to the total loss of individuals from a system for whatever reasons. Wastage can be either voluntary or involuntary. Involuntary wastages arises for reasons beyond the control of individuals such as death, illness, redundancy and retirement and to a large extent it is predictable and it presents few difficulties in manpower planning. On the other hand voluntary or natural wastage refers to the leaving of an individual of his own choice such as taking to another job etc. It is not predictable. The recruitment policy, promotions are all based on the extent of wastage that occur in an organization. In the study of wastage many factors are introduced and it may be noted that the Complete Length Of Service (CLS) plays an important role in the study of manpower models. Forecasting the future wastage is an important aspect of manpower models. Forecasting the future wastage is an important aspect of manpower planning and the cohort analysis. Markov chain models are used in the forecast of wastage. The survivor function of reliability function is also used in the study of wastage and its measurement.

When employees move from one grade to another, they are exposed to different factors influencing them to leave organization. Various data indicate that the reasons for leaving can be classified in to the following cases:

(i) Discharge
(ii) Resignation
(iii) Redundancy
(iv) Medical treatment
(v) Death
(vi) Transfer.

VII STOCHASTIC ANALYSIS OF BUSINESS WITH TWO LEVELS AND MANPOWER WITH THREE LEVELS

7.1 Introduction

Nowadays labor has become a buyers market as well as seller's market. Any company normally runs on commercial basis wishes to keep only the optimum level of any resources needed to meet company's requirement at any time during the course of the business and manpower is not an exception. This is spelt in the sense that a company does not want to keep manpower more than what is required. Hence, retrenchment and recruitment are common and frequent in most of the companies now. Recruitment is done when the business is bust and shed manpower when the business is lean. Equally true with the labor, has the option to switch over to other jobs because of better working condition, better emolument, proximity to their living place or other reasons. Under such situations the company may face crisis because business may be there but manpower may not be available. If skilled laborers and technically qualified persons leave the business the seriousness is worst felt and the company has to hire paying heavy price or pay overtime to employees.

7.2 Assumptions

1. There are three levels of Manpower namely Manpower is full, is moderate and Manpower is nil.

2. There are two levels of business namely (I) business is fully available (2) business is learn or nil.

3. The time T during which the manpower remains continuously moderate and becomes nil has exponential distribution with parameter λ_{10}. The time R required to complete recruitment for filling up of vacancies from level nil to moderate level is exponentially distributed with parameter μ_{01}.
4. The time T during which the Manpower remains continuously full and becomes nil has exponential distribution with parameter λ_{20} and the time R' required to complete full recruitment from nil level is exponentially distributed with parameter μ_{02}.
5. The period of time T'' during which the Manpower is continuously full becomes moderate has exponential distribution with parameter λ_{21} and the period of time R'' required for recruitment from insufficient to full is exponentially distributed with parameter μ_{12}. Random variables T and R; T' and R'; T'' and R'' are all independent.
6. The busy and lean periods of the business are exponentially distributed with parameter $'a'$ and $'b'$ respectively.

MP/B	(0 0)	(0 1)	(1 0)	(1 1)	(2 0)	(2 1)
(0 0)	ε_1	b	μ_{01}	0	μ_{02}	0
(0 1)	a	ε_2	0	μ_{01}	0	μ_{02}
(1 0)	λ_{10}	0	ε_3	b	μ_{12}	0
(1 1)	0	λ_{10}	a	ε_4	0	μ_{12}
(2 0)	λ_{20}	0	λ_{21}	0	ε_5	b
(2 1)	0	λ_{20}	0	λ_{21}	a	ε_6

7.3 System Analysis

The Stochastic Process $X(t)$ describing the state of the system is a continuous time Markov chain with 6 points state space as given below in the order of Manpower and Business

$$S = \{(0\ \ 0), (0\ \ 1), (1\ \ 0), (1\ \ 1), (2\ \ 0), (2\ \ 1)\} \qquad (7.3.1)$$

Where

2 – Refers to full availability in the case of manpower

1 – Refers to semi availability or insufficiently available manpower and it refers to busy period in the case of business.

0 – Refers to shortage/lean/non availability manpower or business.

The infinitesimal generator Q of the continuous time Markov chain of the state space is given below which is a matrix of order 6.

$$\varepsilon_1 = -(\mu_{01} + \mu_{02} + b), \varepsilon_2 = -(\mu_{01} + \mu_{02} + a), \varepsilon_3 = -(\lambda_{10} + \mu_{12} + b),$$

$$\varepsilon_4 = -(\lambda_{10} + \mu_{12} + a), \varepsilon_5 = -(\lambda_{20} + \lambda_{21} + b), \varepsilon_6 = -(\lambda_{21} + \lambda_{21} + a) \qquad (7.3.3)$$

The occurrences of transitions in both manpower and business are independent, the individual infinitesimal generator of them are given by:

1. The infinitesimal generator of business is given below by a matrix of order 2.

$B =$

B	0	1
0	$-b$	b
1	a	$-a$

and the steady state probabilities are $\pi_{B0} = \frac{a}{a+b}$ and $\pi_{B1} = \frac{b}{a+b}$.

2. The infinitesimal generator of manpower is given below by the matrix of order 3,

$M =$

M	0	1	2
0	$-(\mu_{01} + \mu_{02})$	μ_{01}	μ_{02}
1	λ_{10}	$-(\lambda_{10} + \mu_{12})$	μ_{12}
2	λ_{20}	λ_{21}	$-(\lambda_{21} + \lambda_{20})$

The steady state probabilities of manpower are:

$$\pi_{M0} = \frac{d_0}{d_0 + d_1 + d_2}, \pi_{M1} = \frac{d_1}{d_0 + d_1 + d_2}, \pi_{M2} = \frac{d_2}{d_0 + d_1 + d_2}$$

Where $d_0 = \lambda_{20}\mu_{12} + \lambda_{20}\lambda_{10} + \lambda_{21}\lambda_{10}$ $d_1 = \lambda_{20}\mu_{01} + \lambda_{21}\mu_{01} + \lambda_{21}\mu_{02}$

$d_2 = \lambda_{10}\mu_{02} + \mu_{12}\mu_{02} + \mu_{12}\mu_{01}$

The steady state probability vector of the matrix Q can be derived easily by using $\underline{\pi}\, Q = 0$ and $\underline{\pi}\, e = 1$

Steady state Probability	Value
π_{00}	0.0818
π_{01}	0.0922
π_{10}	0.1432
π_{11}	0.1611
π_{20}	0.2455
π_{21}	0.2762
Total	1.0000

$$\pi_{0\ 0} = \frac{ad_0}{Z\sum_0^2 d_i}, \quad \pi_{0\ 1} = \frac{bd_0}{Z\sum_0^2 d_i}, \quad \pi_{1\ 0} = \frac{ad_1}{Z\sum_0^2 d_i}$$

$$\pi_{1\ 1} = \frac{bd_1}{Z\sum_0^2 d_i}, \quad \pi_{2\ 0} = \frac{ad_0}{Z\sum_0^2 d_i} \ \&\ \pi_{2\ 1} = \frac{bd_1}{Z\sum_0^2 d_i} \qquad (7.3.4)$$

where $\sum_0^2 d_i = [d_0 + d_1 + d_2]$ and $Z = (a + b)$

When the business is available, either full manpower or moderate manpower must be available. When it is not so this will create heavy loss, We shall call this situation as crisis.

The crisis state is $\{(0,1)\}$ and the crises occur when there is full business but manpower is NIL.

Now the rate of crisis in steady state (C_∞) is obtained as follows.

$$\begin{aligned} P(\text{crisis in } [t\ t+\Delta t] &= P[X(t+\Delta t) = (0\ \ 1)/X(t) = (0\ \ 0)] \times P[X(t) = (0\ 0)] + P[X(t+\Delta t) \\ &= (0\ \ 1)/X(t) = (2\ \ 1)] \times P[(Xt) = (2\ \ 1)] + P[X(t+\Delta t) = (0\ \ 1)/\mathrm{x}Xt) \\ &= (1\ \ 1) \times P[X(t) = (1\ \ 1)] + O\Delta(t) \end{aligned}$$

Taking limit as $\Delta t \to 0$,

$C_t = bP_{00}(t) + \lambda_{20}P_{21}(t) + \lambda_{10}P_{11}(t)$

$C_\infty = \lim_{t\to\infty}[bP_{00}(t) + \lambda_{20}P_{21}(t) + \lambda_{10}P_{11}(t)]$

That is

$C_\infty = [b\pi_{00} + \lambda_{20}\pi_{12} + \lambda_{10}\pi_{11}]$

Using the steady state probabilities, obtained

$$C_\infty = \frac{b}{ZY}\{ad_0 + \lambda_{20}d_0 + \lambda_{10}d_1\} \qquad (7.3.5)$$

Where $Z = (a + b)$ and $Y = (d_0 + d_1 + d_2)$

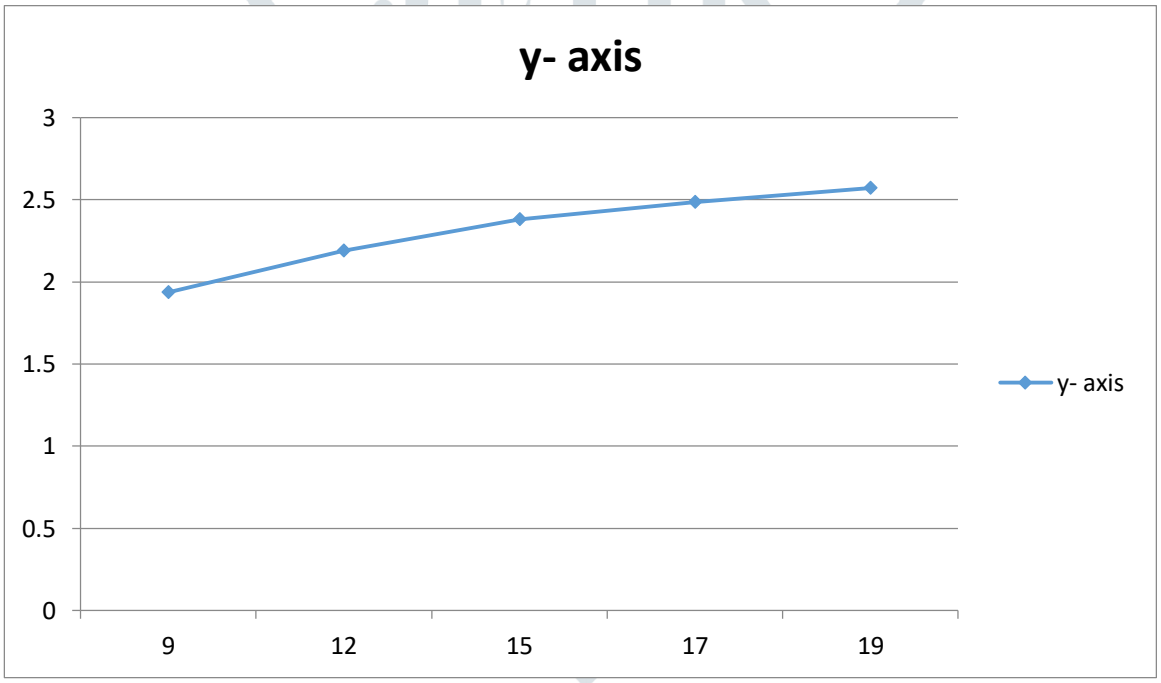
7.4 Numerical Illustration

Now taking the values of the parameters in the model as below, can find the steady probabilities and the rate of crises using the formulas (7.3.4) and (7.3.5) respectively. $\lambda_{10} = 4, \lambda_{21} = 5, \lambda_{20} = 2, \mu_{12} = 8, \mu_{01} = 6, \mu_{02} = 7, a = 8$ and $b = 9$

Now assigning the values $b = 9, 12, 15, 17$ and 19 we calculate the corresponding rate of crisis and is given below in the table:

b	C_∞
9	1.9355
12	2.1913
15	2.3819
17	2.4835
19	2.5701

The graph of the steady crisis is given below taking the values of b on the x-axis and the value of C_∞ on y axis



$b - C_\infty$ graph

The steady state costs in different situations are determind by taking the values:

$C_{MP}^0 = 25 \quad C_{MP}^1 = 15 \quad C_{MP}^2 = 10 \; : \; C_B^0 = 15 \quad C_B^1 = 8$

S.No.	Steady state propability	Cost of state
1	π_{00}	3.2720
2	π_{01}	3.0393
3	π_{10}	4.2960
4	π_{11}	3.7053
5	π_{20}	6.1375
6	π_{21}	4.9716
	Total	24.4217

VIII Conclusion

It is found that as the value of parameter b increase the crisis rate also increases. Also it is observed that the cost of doing business is very heavy if the manpower is full but there is no business. Under such circumstances fetch business at premium rate or offer heavy discount to get business. The cost of business is comparatively low when the business is full and the manpower is also full. Then same holds in the case of manpower is moderate whereas the business may be dull or busy.

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