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A MARKOVIAN STUDY OF MANPOWER PLANNING IN THE SOFT-DRINK INDUSTRY IN NIGERIA

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ABSTRACT
A Markovian approach to the analysis of data pertaining to recruitment, active staff wastage and retirement collected over a period of five years from a soft drink manufacturing company based in Lagos, Nigeria, is presented. Our results suggest that although the company studied has a long term employment policy, staff who retire from the system are disproportionately small 15 to 26 % compared to those who leave through wastage (74-85)%. This paper proposes a review of the current manpower policy to moderate the perceived imbalance in policy structure. The author is convinced that the method advocated is effective as a decision support instrument for solving manpower planning problems in industrial organizations.

Keywords: *Wastage, Absorbing state, Residual stock, Markov chain, Transition matrix*

1. INTRODUCTION
Markovian manpower planning invariably uses information and statistical methods to show probable outcomes of trends and policies in personnel administration. It is the mechanism for examining potential labour problems and assessing strengths and weaknesses of possible solutions. It works with probabilities, continuous feedback and adjustments on a given human resources management approach. The Markovian method of manpower planning can foretell the future. The traditional approach to manpower planning leans heavily on qualitative approach to policy development that appears to be redolent of subjectivity. Most of these methods are replete with canons of rules and guidelines. The Markovian approach proposed in this paper relies on stochastic analysis of past transition of staff through different states over different periods to predict the general human resources policy in the organization concerned. The ensuing analysis reveals both short-term and long-term problems associated with the long-run policies applied to recruitment, promotion, wastage and retirement in the organization studied.

Basically, human resources planning (HRP) comprises the following processes:

- Investigation and analysis,
- Forecasting to determine human resources imbalance or people gap,
- Planning, resourcing and retention activities
- Utilization and control through human resource technique

A vast literature that deals with the application of Markov model to manpower planning exists. A Russian mathematician, Markov, who lived early in the 20th century, defined a class of processes in which the probability of a phenomenon being in a given state at a particular time is related to the immediately preceding state of that phenomenon. A Markov chain may be regarded as a series of transitions between different states such that the probabilities associated with each transition depends only on how the process arrived at that state. Such a chain contains a finite number of states, and the probabilities associated with the transitions between the states do not change with time, i.e. they are stationary. Markov chain is versatile. Shugart, Crow and Hertt [1] has applied it to the modeling of forest succession over large regions. Brinkley [2], Lembersky and Johnson [3], Peden, Williams and Frayer [4], Cassell and Moser [5] dealt with problems arising in forestry. Buongiorno and Michie [6] have also developed a Markov model for selection of forest, where the parameters of the model represent the stochastic transition of trees between

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diameter classes and the recruitment of new trees into the stand. The parameters of this model were estimated from North-Central United States region hardwoods, and the model was used to predict long-term growth of undisturbed and managed strands. Subsequently, a linear programming method was used to determine sustained use of management regimes which would maximize the net present value of periodic harvest. The method allows for the joint determination of optimum- harvests, residual stock, diameter distribution and cutting cycles. No doubt the above forestry application is similar to the Markov chain application to manpower planning. Debussche, Gordon and Lepart [7] describe an agricultural application to the southern end of the French Massif central. This model considered the rural exodus and decrease of sheep grazing, and the best utilization of the grazing resources. The mapping of vegetation types, study of the dynamic changes from one type to another and the definition of key species were used as a basis for the formulation of the model. Vanderveer and Drummond [8] as well as SCOPE organization's handbook have also used Markov processes for estimating land use changes particularly where a major impact such as a reservoir is imposed upon an existing system. Other biological applications of Markov processes include that by Rao and Kshirsagar [9], who made a study of the population dynamics of predator/prey systems in which the attack cycle of a predator is assumed to consist of four different activities namely search, pursuit, handle and eat and, digest Ajayi and Olufayo [10] used Markov chain for the purpose of water resource planning. A semi-Markovian model was proposed to obtain the number of prey devoured by a predator during the activities of a day. The works: Norris [10], Harbaugh and Bonham-Carter [11], and Bhattacharva et al [12] are typical Markovian applications to geology and stratigraphy exist. Moreover, Markovian model has been applied to maintenance and inventory policies development (Kuhn and Madanat, [13]; Yin and Johnson, [14]). Recent applications of Markov chain to manpower planning were carried out by [15], [16] and [17]. The objective of this paper is to collect manpower data dealing with; recruitment, stock and exit over five (5) years from three departments of a Lagos-based soft drink company and employ the data to obtain a stable transition probability matrix (TPM) From this, a fundamental transition probability matrix would be developed and used to predict future manpower needs. The problems associated with the current manpower policy would be examined.

2. METHODOLOGY

Five years data of manpower recruitment, stock, wastage and retirement were obtained from the company studied. As can be seen in the transition probability matrix loop of Figure 1, four stages are involved. A staff recruited from stage four can move to active staff and to retirement if the staff does not get wasted through termination, dismissal, severance, voluntary withdrawal, death, and so forth. The long run movement of staff can be stable and be treated as Markov chain.

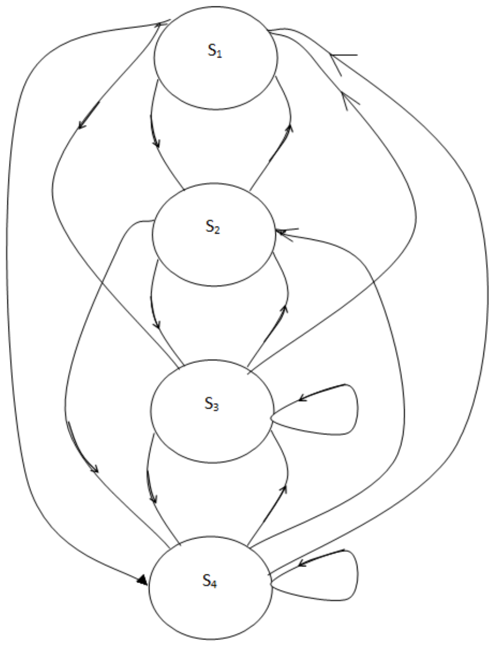

Figure 1: TPM LOOP

The data were taken from the primary records and book of personnel statistics. Purposive and stratified sampling techniques were adopted.

3. THEORETICAL FRAMEWORK

1. From an initial distribution, d_o, of staff among predetermined stages say, for example, wastage, retirement, active staff and recruitment, the future distribution, d_n, some years later is given by:

$$d_n = d_0 T^n \quad (1)$$

2. If $\underset{d}{\rightarrow}$ is the long-run distribution of staff and T the accompanying stable transition matrix, then:

$$d_n = d_0 T \quad (2)$$

3. A Markov chain is called an absorbing chain provided:

i. there are one or more absorbing states, and

- **ii.** from each non-absorbing state it is possible to reach some absorbing state in one or more steps.

4. Consider an absorbing Markov chain with transition matrix Tэ:

$$\overline{T} = {}^{Abs}_{Nonbans}\begin{bmatrix} I & O \\ R & Q \end{bmatrix} \quad (3)$$

In Standard form then,

a) The matrix (I - Q) invertible
b) The power T^n of T approaches

$$\overline{T} = {}^{Abs}_{Nonbans}\begin{bmatrix} I & O \\ (I-Q)^{-1} & O \end{bmatrix} \quad (4)$$

(c) The i^{th} row of the submatrix, B = $(1 — Q)^{-1}R$, specifies the long-run distribution of staff among various absorbing states, i.e. wastage and retirement, provided all staff start in the ith non-absorbing state (recruitment).

5. For an absorbing Markov chain with transition matrix standard form:

(a) the $(ij)^{th}$ entry of N = $(I - Q)^{-1}$specifies the expected or average number of time the object starts in the 1 non-absorbing state before being absorbed.

(b) The sum of the entries across the i^{th} row of N = (I-Q) the expected or average number of states visited by objects starting in the i^{th} non-absorbing state before being absorbed. Equivalently, this is the expected number of transitions prior to absorption.

4. COMPUTATIONS

Five-year data pertaining to staff flow in and out of the human resources system of the organization were obtained. Three departments namely: production, engineering services as well as sales/marketing were studied.

The entries in the first two rows of the fundamental matrices that follow were estimated by heuristic with the aid of TPM loop depicted in figure 1 above. Take, for example, P = 1, i.e the probability that a staff who is wasted, remains wasted. This is a certainty. P = I, i.e the probability that a staff who is retired, remains retired. It is also evident. P = 0, i.e. a staff who is retired cannot become an active staff. This is most unlikely P = 0, the remaining entries in the 1" two rows were similarly determined. Table 1 show the transition probability matrix having the elements of the non-absorbing state namely active staff (S) and recruitment (R).

Table 1: Transition Probability Matrix

To → From ↓	Wastage	Retirement	Active	Redundant
Wastage	1	0	0	0
Retirement	0	1	0	0
Active	0.0350	0.0058	0.9592	0
Redundant	0	0.0051	0.8444	0.1504

The elements of the first two rows, which are the absorbing states, were determined based on Heuristics technique. More compactly, for production (P_1), we have

$$P_1 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.0350 & 0.0058 & 0.9592 & 0 \\ 0 & 0.0051 & 0.8444 & 0.1504 \end{pmatrix} \quad (5)$$

Gathering all the elements of the matrix for engineering services to make the matrix chunkier, we have

$$P_2 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.0347 & 0.0104 & 0.9549 & 0 \\ 0 & 0.0097 & 0.8900 & 0.1003 \end{pmatrix} \quad (6)$$

In the same way, we chunk in the various elements of the matrices for marketing and sales to obtain the matrix.

$$P_3 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.0625 & 0.0208 & 0.9167 & 0 \\ 0 & 0.0172 & 0.7586 & 0.2241 \end{pmatrix} \quad (7)$$

Next, we partition the matrices and determine the product matrix NR. We shall illustrate this with P_1

$$P_1 = \left[\begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 0.0350 & 0.0058 & 0.9592 & 0 \\ 0 & 0.0051 & 0.8444 & 0.1504 \end{array}\right] = \left[\begin{array}{c|c} I & 0 \\ \hline R & Q \end{array}\right]$$

If

$$(I-Q) = \begin{pmatrix} a & c \\ b & d \end{pmatrix},$$

then

$$(I-Q)^{-1} = \frac{1}{ad-bc}\begin{pmatrix} d & -b \\ -c & a \end{pmatrix} = N$$

$$\therefore (I-Q) = \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} 0.9592 & 0 \\ 0.8440 & 0.1504 \end{pmatrix}\right]$$

$$= \begin{pmatrix} 0.0408 & 0 \\ -0.8444 & 0.8496 \end{pmatrix}$$

$$N = (I-Q)^{-1} = \begin{pmatrix} 24.4842 & 0 \\ 24.3343 & 1.1758 \end{pmatrix} \quad (8)$$

$$NR_1 = \begin{pmatrix} 24.4842 & 0 \\ 24.3343 & 1.1758 \end{pmatrix}\begin{pmatrix} 0.0350 & 0.0058 \\ 0 & 0.0051 \end{pmatrix}$$

$$NR_1 = \overset{\quad Wastage \quad Retirement}{\begin{pmatrix} 0.8569 & 0.1442 \\ 0.8517 & 0.1477 \end{pmatrix}} \quad (9)$$

Similarly, for Engineering Services

$$NR_2 = \overset{\quad Wastage \quad Retirement}{\begin{pmatrix} 0.7690 & 0.2305 \\ 0.7607 & 0.2388 \end{pmatrix}} \quad (10)$$

And finally for marketing and sales

$$NR_3 = \overset{\quad Wastage \quad Retirement}{\begin{pmatrix} 0.7501 & 0.2498 \\ 0.7339 & 0.2665 \end{pmatrix}} \quad (11)$$

The detailed computation for Engineering Services and marketing/sales department is shown in Appendices A and B.

It is evident from equation (8), which applies to production department that the long-run managerial implication of the stabilized matrix (see equation 9) is that 85% of the staff recruited into production department often leave the service of the company through severance(wastage) while about 15% leave through normal retirement. In engineering services, see equation (9), 77% and 23% respectively were noted. However, in marketing/sales, wastage and retirement figures were found to be 75% and 25% respectively (see theorem 4 (c)). On the other hand, a close examination of the row sum of equation (8), which applies to production department, and similar equations for engineering services as well as sale/marketing department respectively, leads to a different interpretation (see theorem 5 (b)). For Production department, we have:

$$N_1 = (I-Q)^{-1} = \overset{Retirement \quad Recruitment \quad Row\ Sum}{\begin{pmatrix} 24.48.42 & 0.0170 \\ 24.3343 & 1.1758 \end{pmatrix}}\begin{matrix} 24.5012 \\ 25.5101 \end{matrix}$$

The managerial implication is that some workers who are recruited in the production department on the average go through 25 positions in the company hierarchy before disengagement. This type of manpower policy depicts that staff are regularly moved to different positions over the years. On the other hand, people who go through normal retirement appear to experience similar promotions to different positions. Furthermore, the matrix above shows the average number of times which a staff in the recruitment position starts and moves through various positions before reaching the absorbing states such as wastage or retirement. Since the two row matrices are virtually the same, the implications is that their manpower policy appears to be favourable in the sense that a recruited staff goes through virtually all job positions before disengagement. The import is that such a staff tends to acquire a wealth of experience that can enable him/her become a generalist who knows a little about more. The associated row sums for engineering services department is as follows:

$$N_2 = (I-Q)^{-1} = \overset{Retirement \quad Recruitment \quad Row\ Sum}{\begin{pmatrix} 22.1601 & 0 \\ 21.9212 & 1.1108 \end{pmatrix}}\begin{matrix} 22.1601 \\ 23.0320 \end{matrix}$$

And, for Sales/Marketing department, we have:

$$N_3 = (I-Q)^{-1} = \overset{Retirement \quad Recruitment \quad Row\ Sum}{\begin{pmatrix} 12.0108 & 0 \\ 11.7430 & 1.2895 \end{pmatrix}}\begin{matrix} 12.0108 \\ 13.3225 \end{matrix}$$

5. DISCUSSION

A major feature of the manpower policy for the company studied, as highlighted by Markovian model, is that staff recruited into any of the three departments, on the average, pass through seal stages before reaching any of the two absorbing states. The production and engineering services departments are the key areas in which staff move through about 24 positions, whereas in Marketing/Sales department, the average number of positions passed is between 12 and 13. It is therefore probable that staff who are recruited stay long in the company and are effectively used by the company. Another major feature of their manpower policy is that staffare used until they are forced by circumstances to leave. Only about 23% leave through the normal retirement and hence get the full benefit. It would appear that although they are good and fair in long-run employment policy, the percentage of people who leave by wastage appear to be very high compared to those who leave by normal retirement. This tendency may require a physical review or structural adjustment in policy to favour the greater percentage of people who leave by wastage. It is better that they retire much earlier and are given entitlement than to cause workers to leave through sickness or similar circumstance. Indeed a critical review is inevitable. On the other hand, another major feature is that there appears to be frequent reassignment promotion to different positions in the organization's hierarchy. However, the Markov chain model employed is not able to ascertain whether or not the positions occupied were commensurate with the pay attached to the positions or authority delegated. Good manpower policy should address this last case. Comparatively, production seems to have the highest percentage wastage of staff recruited; 85% go through wastage while 15% leave the services of the company through normal retirement.

This is awfully bad because production staff are comparable to the bee workers who produce honey but the queen and drones feed on it. The queen here represents top management while the soldiers represent the line managers, and the bee workers represent the production staff. The engineering services department perhaps, experiences the same fate. About 77% of them go through wastage while 23% leave through normal retirement. The workers of the engineering department are as essential as that of the Production department. Their functions are centred on maintenance of utilities and facilities used for soft-drink production. The Production workers produce the soft drinks. Similarly, to a lesser extent, 75% of workers recruited into Marketing/Sales department leave by wastage. Only 25% leave through normal retirement.

6. CONCLUSION

The study has fruitfully demonstrated the effective application of Markov chain to manpower planning situation. The pattern of manpower policy of the company appears to be that, for staff recruited into the company, between 15-26% is retired normally and gets their full retirement benefits while between 74-85% leave the company through wastage. The overall implication is that although the company has a fair long-term employment policy as it has been shown by the Markov chain model employed, it would appear that people are used to the point of exhaustion in order to achieve profitability and in the process only few survive the rigour. It appears also that the human struggle of survival of the fittest, a social version of Charles Darwin evolutionary theory is operational. Only the most competent and resourceful make it in life while the rest fizzle out.

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APPENDIX A: COMPUTATIONAL DATA FOR ENGINEERING SERVICES

P_2 is obtained thus

To → From ↓	Wastage	Retirement	Active Staff	Recruitment
Wastage	1	0	0	0
Retirement	0	1	0	0
Active Staff	0.0347	0,0104	0.9542	0
Recruitment	0	0.0097	0.8900	0.1003

$$P_2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.0347 & 0.0194 & 0.9549 & 0 \\ 0 & 0.0097 & 0.8900 & 0.1003 \end{bmatrix}$$

Next, we partition the matrix and determine the product matrix NR

$$P_2 = \left[\begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 0.0347 & 0.0194 & 0.9549 & 0 \\ 0 & 0.0097 & 0.8900 & 0.1003 \end{array}\right] = \left[\begin{array}{c|c} I & 0 \\ \hline R & Q \end{array}\right]$$

$$(I-Q) = \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} 0.9549 & 0 \\ 0.8900 & 0.1003 \end{pmatrix}\right]$$

$$N = (I-Q)^{-1} = \begin{pmatrix} 22.156 & 0 \\ 21.932 & 1.1114 \end{pmatrix}$$

Then NR_2 is obtained thus:

For Engineering Services

$$R_2 = \begin{pmatrix} 0.0347 & 0.0104 \\ 0 & 0.0097 \end{pmatrix}$$

$$NR_2 = \begin{pmatrix} 22.156 & 0 \\ 21.932 & 1.1114 \end{pmatrix} \begin{pmatrix} 0.0347 & 0.0104 \\ 0 & 0.0097 \end{pmatrix}$$

$$NR_2 = \begin{pmatrix} \overset{Wastage}{0.8569} & \overset{Retirement}{0.1442} \\ 0.8517 & 0.1477 \end{pmatrix}$$

APPENDIX B: COMPUTATIONAL DATA FOR MARKETING AND SALES

P_3 is obtained thus

To → From ↓	Wastage	Retirement	Active Staff	Recruitment
Wastage	1	0	0	0
Retirement	0	1	0	0
Active Staff	0.0625	0.0208	0.9187	0
Recruitment	0	0.0172	0.7586	0.2241

$$P_3 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.0625 & 0.0208 & 0.9187 & 0 \\ 0 & 0.0172 & 0.7586 & 0.2241 \end{bmatrix}$$

Next, we partition the matrix and determine the product matrix NR

$$P_3 = \left[\begin{array}{cc|cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hline 0.0625 & 0.0208 & 0.9167 & 0 \\ 0 & 0.0172 & 0.7586 & 0.2241 \end{array}\right] = \left[\begin{array}{c|c} I & 0 \\ \hline R & Q \end{array}\right]$$

$$(I-Q) = \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} 0.9167 & 0 \\ 0.7586 & 0.2241 \end{pmatrix}\right]$$

$$N = (I-Q)^{-1} = \begin{pmatrix} 12.067 & 0 \\ 11.7978 & 1.295 \end{pmatrix}$$

Then NR_2 is obtained thus:

For Engineering Services

$$R_3 = \begin{pmatrix} 0.0625 & 0.0208 \\ 0 & 0.0172 \end{pmatrix}$$

$$NR_3 = \begin{pmatrix} 12.067 & 0 \\ 11.7978 & 1.295 \end{pmatrix} \begin{pmatrix} 0.0625 & 0.0208 \\ 0 & 0.0172 \end{pmatrix}$$

$$NR_3 = \begin{pmatrix} \overset{Wastage}{0.7542} & \overset{Retirement}{0.2509} \\ 0.7374 & 0.2677 \end{pmatrix}$$