



**MARKOV CHAIN ANALYSIS OF EMPLOYEES SAFETY DATA: A CASE STUDY OF
POWER GENERATION COMPANY**

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ABSTRACT

The research work objective is using Markov Chain Model to analyze employee safety performance by way of compliance to safety and management commitment to performance using Benin Power Generation Company as a case study. In that regard a Seven (7) years incidents records (2013 – 2019) comprising of fatality, unsafe acts, unsafe conditions, near misses, fire incident and medical treatment, the data was analyzed using Markov Chain model. Markov chain model analytical tool shown that on the average, employees had committed seven (7) near-misses, unsafe acts, unsafe condition or fire incident before actually undergoing real medical treatment or fatality. Employees in the company that is involve in an incident of near misses, unsafe acts, unsafe condition and fire incident has a probability of 0.04 chance of leaving the company through fatality while employees in the company that is involve in an incident of near misses, unsafe acts, unsafe condition and fire incident has a probability of 0.96 chance to be involved in an incident that will lead to medical treatment.

Keywords: Employee safety, Absorbing state, Non-absorbing state, Markov Chain, Transition matrix

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1.0 INTRODUCTION

Markov Model are descriptive, non-optimizations models. They are linear and as such exclude feedback mechanism. The number of people in class (sample size) must be large otherwise the transition probability estimates will tend to be unstable. Thus, workforce sizes of tens are not appropriate for Markov chains modeling. The minimum staff strength is hundred.

Researcher have paid considerable attention to Markov manpower models under some specific assumption in which the system behaves asymptotically over time (De Feyter, 2007). The attainability and problem of a manpower system is a major concern of operational research as observed by (Guerry and De Feyter, 2009).

Scott and Farley (1969) reported on the use of Markov chains in forecasting store choice. The objective of the research was to analyze the Ehrenberg's vid criticism of Markov brand switching models for aggregate analysis of consumer behaviour. There was a slight predictive advantage over the on-change model for short term planning of super market choices for 45 families' sample. The research concluded that the marginal advantage of markovian model outweighs the increased cost of using such a model, but the no-change model has merit in simplicity and to applying control-chart types of procedures to track series of stability over time.

Igboanugo and Edokpia (2008) researched on markovian planning in a soft drink industry in Lagos, Nigeria. The research focused on the short-term and long-term challenges with regard to long-run policies as it applied to absorbing states (retirement, promotion, wastage, and recruitment). Transition probabilities matrix were generated and computed. There was high wastage rate of between 74-85% and those who retire normally from the system are between 15-16%. The salient point of the research shows that the organization maximizes profit at the expense of the employees hence only few endure and transits to retirement state.

2.0 METHODOLOGY

The Markov Chain Modeling was used to model Employee Safety Report, and the procedural steps adopted is enumerated below (Ezugwu; Ologun, 2017):

- i. Evaluation of transition probability matrix, T

$$T = \begin{bmatrix} P_{11} & P_{12} & P_{13} & \dots & P_{1K} \\ P_{21} & P_{22} & P_{23} & \dots & P_{2K} \\ \dots & \dots & \dots & \dots & \dots \\ P_{K1} & P_{K2} & P_{K3} & \dots & P_{KK} \end{bmatrix} \quad (1)$$

$$P_{ij} = \{ \xi_{t_n} = j \mid \xi_{t_{n-1}} = i \}$$

- ii. One-step transition probability of transition from i at t_{n-1} to state j at t_n . Assumed that T is stationary.

$$\sum P_{ij} = 1 \quad \forall i$$

$$\sum P_{ij} \geq 0, \quad \forall i \text{ and } j$$

- iii. Partitioned matrix, i.e. the fundamental matrix was established
- iv. Markov theories was used for the interpretation.

2.1 Modeling with Markov chain

2.1.1 Theoretical Brief

Markov chain can model circumstances if it can be observed as the repeated movement of one or more objects between different classification and states. (Igboanugo and Edokpia 2014). Let the states been characterized by $X_1, X_2, X_3, \dots, X_n$. For each pair (X_i, X_j) , let a fixed proportion P_{ij} of object situated at X_i move to X_j during each movement. (Folarin and Onifade, 2019) Thus the scenario can be signified in a transition probability Matrix as

$$T = \begin{matrix} & \begin{matrix} X_1 & X_2 & X_3 & \dots & X_K \end{matrix} \\ \begin{matrix} X_1 \\ X_2 \\ X_3 \\ \dots \\ X_K \end{matrix} & \begin{bmatrix} P_{11} & P_{12} & P_{13} & \dots & P_{1K} \\ P_{21} & P_{22} & P_{23} & \dots & P_{2K} \\ P_{31} & P_{32} & P_{33} & \dots & P_{3K} \\ \dots & \dots & \dots & \dots & \dots \\ P_{K1} & P_{K2} & P_{K3} & \dots & P_{KK} \end{bmatrix} \end{matrix} \quad (2)$$

$T_{ij} = P_{ij}$ = Probability that an object in state i move, to state j .

2.1.2 Theorem 1

In Igboanugo and Edokpia (2014); Folarin and Onifade (2019), initial distribution of an object in a Markov chain, can move through many transition to attain a long-run distribution, d_n and therefore to achieve a stable transition distribution probability matrix \bar{T}_L with stabilized distribution,

$$d_n = d_0 T^n \quad (3)$$

2.1.3 Theorem 2

In Igboanugo and Edokpia (2014); Folarin and Onifade (2019), if as the number of transitions increase $(n \uparrow)$ the powers T^n of the transition matrix T approach a matrix \bar{T} , then for each choice of an initial distribution d_0 , the preceding distributions $d_n = d_0 T^n$ steady to the long run distribution \bar{d}

$$\text{given by } \bar{d} = d_0 \bar{T} \quad (4)$$

Furthermore, each \bar{d} arising in this fashion is stationary.

2.1.4 Theorem 3

In Igboanugo and Edokpia (2014); Folarin and Onifade (2019), let the transition matrix of a regular Markov chain be T. Then the power of T reaches a matrix \bar{T} with long-run distribution, \bar{d} all of whose rows are same and all entries positive. The practical problem of actually computing the unique long-run distribution \bar{d} associated with \bar{T} of regular Markov chain remains. $d = dT$

For stationary d and regular dT

$$dI = dT$$

$$dI - dT = 0$$

$$\text{and } d(I - T) = 0 \tag{5}$$

Take the transpose

$$\Rightarrow \theta (I - T)^t d^t = 0^t \Leftarrow AX = 0 \tag{6}$$

The Equation is a homogeneous system and this leads us to theorem 4.

2.1.5 Theorem 4

Markov chain with k states has at least one long-run distribution. Furthermore, each long-run distribution is the transpose of an answer to: $AX=0$, whose entries sum to 1. (Igboanugo and Edokpia, 2014; Folarin and Onifade, 2019)

$$\text{Here, } A = (I - T)^t, \tag{7}$$

$T = k - by - k$ transition matrix and both X and 0 are $k - by - 1$ column vectors.

2.1.6 Theorem 5

Consider as absorbing Markov chain with transition matrix $T \ni$: (Igboanugo and Edokpia, 2014; Folarin and Onifade, 2019)

Abs Nonabs

$$\bar{T} = \begin{matrix} \text{Abs} \\ \text{Nonabs} \end{matrix} \begin{bmatrix} I & O \\ R & Q \end{bmatrix} \tag{8}$$

In standard form then,

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

$$\bar{T} = \begin{matrix} \text{Absorbing} \\ \text{Non - Absorbing} \end{matrix} \begin{bmatrix} I & \dots & O \\ \dots & \dots & \dots \\ (I - Q)^{-1} R & \dots & O \end{bmatrix} \tag{9}$$

The i^{th} row of the sub matrix $B = (I - Q)^{-1} R$ detailed the long-run distribution of objects amongst the different absorbing states provided all object start in the i^{th} non-absorbing state.

2.1.7 Absorbing Markov Chain

Markov chain is absorbing if it has at least one absorbing state, and if from every single state it is likely to go to an absorbing state (not necessarily in one step). And defined as one who state space consisted only of transient (Non-absorbing) states and absorbing states

2.1.8 Canonical Forms

Transition matrices can be used to develop the theory of Absorbing Markov chain in canonical form. In doing so, the row and columns (absorbing states and transient states) are rearranged so that all the absorbing states are treated with first. Their transition probabilities appear together in the top left hand portion of T, with unities (1s) in the leading diagonal. Then the row and columns for the transition matrix will be

$$T = \begin{matrix} s \\ t \end{matrix} \left[\begin{array}{cc} \underline{S} & \underline{t} \\ I & O \\ R & Q \end{array} \right] \quad (10)$$

Where: I is an $X \times X$ unit matrix

O is a $s \times t$ matrix of zero elements

R is a $t \times s$ matrix concerned with transit to absorbing states,

Q is a $t \times t$ matrix concerned with transitions from transient states to transient states.

2.1.9 Fundamental Matrix

If Q is a $t \times t$ sub-matrix of the canonical absorbing transition matrix, and I is $t \times t$ unit matrix, then the fundamental matrix of the chain is $N = (I - Q)^{-1}$

The following quantities are of the major interest in the study of absorbing Markov chains:

- i. The mean and variance of the total number of event the chain is in a certain state X_j , given that it began in a transient, X_j .
- ii. The mean and variance of the total number of event the chain is in a certain transient state, X_j .
- iii. The probability that the procedure is ‘trapped’ in the absorbing state, X_j given that it started the transient state, X_j

2.1.10 Computing Formulae for Cases 1, 2 and 3

2.1.10.1 Case 1

Let n, be the total number of time that an absorbing chain is in a transient states X_i (including the initial position). We require the mean and variance of n_j given that the procedure began in transient states X_i (note that the starting state may possibly be X_j).

Let the mean $= E_i(n_j)$ and variance $= \text{vari}(n_j)$ respectively then $E_i(n_j)$ = the ijth element of N, and $\text{vari}(n_j)$ = the ijth element of N_2 .

where

$$N_2 = N(2N_{dg} - I) - N_{sq}$$

$$N = (I - Q)^{-1} \quad (11)$$

$$N = \begin{pmatrix} a & b \\ c & d \end{pmatrix}, \text{ then}$$

$$\text{Suppose } N_{dg} = \begin{pmatrix} a & 0 \\ 0 & d \end{pmatrix} \text{ and } N_{sq} = \begin{pmatrix} a^2 & b^2 \\ c^2 & d^2 \end{pmatrix} \tag{12}$$

And by ij^{th} element of N, we mean the element at the intersection of the row for X_i and the column for X_j .

2.1.10.2 Case 2

Let t be the number of times an absorbing chain moves among the transient states (including the original position) before passing to one of the absorbing states. Denote the mean and variance of t , given that the chain started in transient state S_1 , by $E_i(t)$ and $Var_i(t)$ respectively. Then,

- a) $E_i(t)$ is the element of the column vector/matrix $\tau = N\xi$,
- b) $Var_i(t)$ is the i^{th} element of the column vector/matrix $\tau_2 = (2N - I)\tau - \tau_{sq}$,
- c) ξ is an appropriate unit column vector/matrix

2.1.10.3 Case 3

Let b_{ij} be the probability that an absorbing chain arrives in absorbing state X_j , given that it began in transient state X_i . Therefore, b_{ij} is the ij^{th} term of the matrix $B = NR$

2.1.11 Matrix and Vectors

Fundamental matrix:

$$N = (I - Q)^{-1}$$

$$N_2 = N(2N_{dg} - I) - N_{sq} \tag{13}$$

Table 1: Annual Workers’ Safety Report for Seven (7) Years

| YEAR | UNSAFE ACTS | UNSAFE CONDITION | NEAR MISSES | FIRE INCIDENT | MEDICAL TREATMENT | FATALITY |
|-------|-------------|------------------|-------------|---------------|-------------------|----------|
| 2013 | 46 | 51 | 122 | 74 | 37 | 1 |
| 2014 | 26 | 36 | 91 | 81 | 19 | 0 |
| 2015 | 32 | 23 | 73 | 79 | 28 | 2 |
| 2016 | 27 | 59 | 109 | 61 | 18 | 0 |
| 2017 | 23 | 67 | 82 | 57 | 25 | 2 |
| 2018 | 37 | 28 | 73 | 52 | 18 | 3 |
| 2019 | 34 | 46 | 85 | 59 | 30 | 2 |
| TOTAL | 225 | 310 | 635 | 463 | 175 | 10 |

Table 1 is the raw data collected from the Power Generation Company of Nigeria which will be used for the analysis, in that regard a Seven (7) years incidents records (2013 – 2019) comprising of fatality, unsafe acts, unsafe conditions, near misses, fire incident and medical treatment, the data was analyzed using Markov Chain Model.

2.1.12 Assumption

Employee cannot transit from unsafe act incident and unsafe condition incident straight to fatality. This is guaranteed by not engaging a freshly employed employee in a task that has the potential to cause a fatality. Hence by heuristic the probability that an employee will transit from unsafe act incident and unsafe condition incident to fatality incident state is zero.

Employee who regularly commits near misses has some probability of getting involved in a medical treatment or fatality and is not expected to fall back into an unsafe act incident and unsafe condition. Therefore the probability of moving from near miss incident state to unsafe act incident and unsafe condition is zero.

Fire incident, in this framework, is defined as an incident that does not lead accident or fatality. Hence by heuristic the probability that an employee will transit from illness to fatality and medical treatment cost state is zero

Accident, in this framework, is defined as an incident that causes serious injury, bodily harm or impairment that leads to incapacitation. The victim therefore is unable to work normally. He then enters an absorbing state.

Table 2: Transition Probability Matrix of Absorbing and Non-Absorbing States

| STATES | TO | FATALITY | MEDICAL TREATMENT | NEAR MISSES | UNSAFE ACTS | UNSAFE CONDITION | FIRE INCIDENT | SUM TO OF THE ROW |
|----------------------|-------------------|----------|-------------------|-------------|-------------|------------------|---------------|-------------------|
| | FROM | | | | | | | |
| ABSORBING STATES | FATALITY | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| | MEDICAL TREATMENT | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| NON-ABSORBING STATES | NEAR MISSES | 0.00738 | 0.166052 | 0.468635 | 0.129151 | 0.228782 | 0 | 1 |
| | UNSAFE ACTS | 0.006631 | 0.116048 | 0.421088 | 0.149204 | 0 | 0.307029 | 1 |
| | UNSAFE CONDITION | 0.006277 | 0.109856 | 0.398619 | 0 | 0.194601 | 0.290647 | 1 |
| | FIRE INCIDENT | 0 | 0.096792 | 0.351217 | 0.124447 | 0.17146 | 0.256084 | 1 |

Transition Probability Matrix of absorbing and non-absorbing State, the elements of the TPM for absorbing and non-absorbing states were calculated as shown above Table 6

$$M = \begin{bmatrix} 0.468635 & 0.129151 & 0.228782 & 0 \\ 0.421088 & 0.149204 & 0 & 0.307029 \\ 0.398619 & 0 & 0.194601 & 0.290647 \\ 0.351217 & 0.124447 & 0.17146 & 0.256084 \end{bmatrix} \quad I = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad J = \begin{bmatrix} 0.00738 & 0.166052 \\ 0.006631 & 0.116048 \\ 0.006277 & 0.109856 \\ 0 & 0.096792 \end{bmatrix} \quad (14)$$

From this initial distribution d_0 , if it transit to another state.

It is well know that every object in a non-absorbing state eventually enters in any of the absorbing state after a long run transition.

$$\bar{T} = \begin{bmatrix} I & O \\ (I-Q)^{-1}R & O \end{bmatrix}$$

Where $R = d_0 = \begin{bmatrix} \vdots \\ \vdots \\ \vdots \end{bmatrix}$ = long-run distribution to absorbing states

The i^{th} row of the sub matrix $B = (I - Q)^{-1}R$ specify the long-run distribution of objects among the various absorbing states provided all objects start in the i^{th} Non-absorbing state. (Folarin and Onifade, 2019)

Set $N = (I - Q)^{-1}$,

$B=NR$

3.0 RESULTS AND DISCUSSION

The Employee Safety Report data obtained from the company are analysed and results are presented below

Table 3: The Value of Q

| STATES | TO | NEAR MISSES | UNSAFE ACTS | UNSAFE CONDITION | FIRE INCIDENT | SUM OF ROW |
|----------------------|------------------------|-------------|-------------|------------------|---------------|------------|
| | FROM | X_3 | X_4 | X_5 | X_6 | |
| NON-ABSORBING STATES | NEAR MISSES X_3 | 0.4686 | 0.1292 | 0.2288 | 0 | 0.8266 |
| | UNSAFE ACTS X_4 | 0.4211 | 0.1492 | 0 | 0.3070 | 0.8773 |
| | UNSAFE CONDITION X_5 | 0.3986 | 0 | 0.1946 | 0.2906 | 0.8838 |
| | FIRE INCIDENT X_6 | 0.3512 | 0.1244 | 0.1715 | 0.2561 | 0.9032 |

From the above Table 7, we can see that value of Q, is a $t \times t$ matrix which is concerned with transitions from transient states to transient states and also arbitrary matrices belonging to non-absorbing states.

Table 4: The Value of R

| STATES | TO FROM | FATALITY X_1 | MEDICAL TREATMENT X_2 |
|------------------------------|-------------------------|----------------------|-------------------------------|
| | NON-ABSORBING STATES | NEAR MISSES X_3 | 0.0074 |
| UNSAFE ACTS X_4 | | 0.0066 | 0.1160 |
| UNSAFE CONDITION X_5 | | 0.0063 | 0.1099 |
| FIRE INCIDENT X_6 | | 0 | 0.0968 |

From the above Table 8, we can see that value of R is a $t \times s$ matrix which is concerned with transit to absorbing states, which is the initial state distribution.

Table 5: The Values of B

| STATES | TO FROM | FATALITY X_1 | MEDICAL TREATMENT X_2 | SUM OF ROW |
|------------------------------|-----------------------------|----------------------|-------------------------------|---------------|
| | NON- ABSORBING STATES | NEAR MISSES X_3 | 0.0420 | 0.9580 |
| UNSAFE ACTS X_4 | | 0.0417 | 0.9583 | 1 |
| UNSAFE CONDITION X_5 | | 0.0417 | 0.9583 | 1 |
| FIRE INCIDENT X_6 | | 0.0364 | 0.9636 | 1 |

From the above Table 9, $B = NR = Nd_0$. The Value of B provides the long-run distribution of employee on the field. Using it, we estimate the probability that employee starting in any of the non-absorbing states can end up in any of the absorbing states. The initial state distribution (d_0) is R (Table 8. The Value of R). B Matrix represents the Transition of Employee which is given in Table 9 Recall that the initial state distribution is R (Table 8.). The initial distribution, when multiple by the fundamental matrix, N given Matrix B which is a probability distribution. The row sum equal one. N is the basic manipulation tool for forecasting expected changes in the initial organization of the safety policies.

Table 6: The Value of N

| STATES | TO | NEAR MISSES | UNSAFE ACTS | UNSAFE CONDITION | FIRE INCIDENT | SUM OF ROW |
|----------------------|------------------------|-------------|-------------|------------------|---------------|------------|
| | FROM | X_3 | X_4 | X_5 | X_6 | |
| NON-ABSORBING STATES | NEAR MISSES X_3 | 3.9476 | 0.7163 | 1.2917 | 0.8003 | 6.756003 |
| | UNSAFE ACTS X_4 | 3.0666 | 1.8147 | 1.1240 | 1.1881 | 7.193376 |
| | UNSAFE CONDITION X_5 | 3.0666 | 0.6393 | 2.3656 | 1.1881 | 7.259627 |
| | FIRE INCIDENT X_6 | 3.0835 | 0.7891 | 1.3431 | 2.1947 | 7.410451 |

From the above Table 10, the value of N which is an estimate of the number of times employee starting from non-absorbing states to non-absorbing states before absorption into absorbing states. Number of employees make in a particular non-absorbing state as well as the standard deviation of such estimates of the Table 10. The value of N, is the interpretation of this Table 10. Matrix is significant.

Table 7: The Value Of N_2

| STATES | TO | NEAR MISSES | UNSAFE ACTS | UNSAFE CONDITION | FIRE INCIDENT |
|----------------------|------------------------|-------------|-------------|------------------|---------------|
| | FROM | X_3 | X_4 | X_5 | X_6 |
| NON-ABSORBING STATES | NEAR MISSES X_3 | 11.6363 | 1.3703 | 3.1513 | 2.0721 |
| | UNSAFE ACTS X_4 | 11.7411 | 1.4783 | 2.9306 | 2.6154 |
| | UNSAFE CONDITION X_5 | 11.7411 | 1.2722 | 3.2307 | 2.6154 |
| | FIRE INCIDENT X_6 | 11.7537 | 1.4521 | 3.2076 | 2.6220 |

From the above Table 11, the Value Of N_2 provides interesting information about the variance of the estimate of $N = (I - Q)^{-1}$. The N_2 derivatives, namely standard deviation (σ) (Table 12. The Value of σ) to report the possible variability of the estimate of N.

Table 8: The Value of σ

| STATES | TO | NEAR MISSES | UNSAFE ACTS | UNSAFE CONDITION | FIRE INCIDENT |
|----------------------|------------------------|-------------|-------------|------------------|---------------|
| | FROM | X_3 | X_4 | X_5 | X_6 |
| NON-ABSORBING STATES | NEAR MISSES X_3 | 3.4112 | 1.1706 | 1.7752 | 1.4395 |
| | UNSAFE ACTS X_4 | 3.4265 | 1.2159 | 1.7119 | 1.6172 |
| | UNSAFE CONDITION X_5 | 3.4265 | 1.1279 | 1.7974 | 1.6172 |
| | FIRE INCIDENT X_6 | 3.4283 | 1.2050 | 1.7910 | 1.6193 |

From the above Table 12, we can see that the total number of habituations staff undertook among all the non-absorbing states before being trapped in any of the absorbing state. The associated standard variations are also important.

Near misses is 6.7560, unsafe acts is 7.1934, unsafe condition is 7.2596 and fire incident is computed to be 7.4105

Markov chain transiting among states space, $X = \{X_1, X_2, \dots, X_6\}$. From the diagraph we discover that it is a non-cyclic chain (regular). State 1, 2 are absorbing states while states 3, 4, 5, 6 are non-absorbing states showing that object accustom in step-wise fashion among these states before being trapped in states 1, or 2. From the analysis three sets of results were obtained that were considered very significant. The mean and variance of Markov chain among transient states.

Accordingly:

$$\text{Mean, } N = (I - Q)^{-1} \tag{15}$$

The fundamental matrix, N, is:

$$N = (I - Q)^{-1}$$

$$N = A^{-1} = \text{inv}(A)$$

$$\tag{16}$$

1. Number of employee make in a particular non-absorbing state as well as the standard deviation of such estimates of the Table 10.: The value of N, the interpretation of this Table 10. matrix is significant... Table 11.: The Value Of N_2 provides interesting information about the variance of the estimate of $N = (I - Q)^{-1}$. The N_2

- derivatives, namely standard deviation (σ) (Table 12. The Value of σ) to report the possible variability of the estimate of N.
2. The Total number of Employee that undertook among all the non-absorbing states before being trapped in any of the absorbing state (Table 13. The value of τ and Table 14. The value of $(\tau_2$ variance to τ)). The associated standard variations are also important (Table 10: The Value of σ_τ (standard derivation to τ)).
 3. $B = NR = Nd_0$. The Table 9: The Value of B provides the long-run distribution of employee on the field. Using it, we estimate the probability that employee starting in any of the non-absorbing states can end up in any of the absorbing states. The initial state distribution (d_0) is R (Table 8. The Value of R).

3.1 Interpretation of the Fundamental Matric

Table 10: The value of N which is an estimate of the number of times employee starting from non-absorbing states to non-absorbing states before absorption into absorbing states. Table 11: The Value Of N_2 and Table 12: The Value of σ gives the variability (variance) and standard deviation associated with N.

The safety activities of employee shall be interpreted as depicted by entries of N one after the other. The following interpretations are valid as shown clear from the matrix

- a. From $X_6 \rightarrow X_3, X_5 \rightarrow X_3$ and $X_4 \rightarrow X_3$: At least Three Employees on the experiencing fire incident, Unsafe Condition And Unsafe Acts can also be involve in Near misses, this estimate is not subjective to variation since σ is 3.4. While $X_3 \rightarrow X_3$ at least Three Employees experience near misses, this estimate is not subjective to variation since σ is 3.4.
- b. From $X_6 \rightarrow X_4, X_5 \rightarrow X_4$ and $X_3 \rightarrow X_4$: At least One Employee on the experiencing Fire incident, Unsafe Condition And Near Misses can also be involve in Unsafe Acts, this estimate is not subjective to variation since σ is 1.2. While $X_4 \rightarrow X_4$ at least One Employees experience near Unsafe Acts, this estimate is not subjective to variation since σ is 1.2.
- c. From $X_6 \rightarrow X_5, X_4 \rightarrow X_5$ and $X_3 \rightarrow X_5$: At least One and at most Two Employees on the experiencing Fire incident, Unsafe Acts And Near Misses can also be involve in Unsafe conditions, this estimate is not subjective to variation since σ is 1.8. While $X_5 \rightarrow X_5$ at least One and at most Two Employees experience Unsafe Conditions, this estimate is not subjective to variation since σ is 1.8.
- d. From $X_6 \rightarrow X_5$ and $X_4 \rightarrow X_6$: At least One and at most Two Employees involve Unsafe Acts And Unsafe Condition can also be experiencing in Fire incident, this estimate is not subjective to variation since σ is 1.6 and $X_3 \rightarrow X_6$: At least One Employee that is involved Near Misses can also be experiencing Fire incident, this

estimate is not subjective to variation since σ is 1.4. While $X_6 \rightarrow X_6$ at least One and at most Two Employees experience Unsafe Conditions, this estimate is not subjective to variation since σ is 1.6.

3.2 Total Movement of Employee within the Non-Absorbing States Before Being Absorbed:

τ Matrix represents the movement of employee which is shown in Table 13.. The associated variance and standard variation is on Table 14. and Table 15. respectively. It is evident from the entries of τ that employee on the average change position 7 times at each of the transient states before being trapped in any of the absorbing states.

3.3 Long Run Transition of Employee Within the System:

B Matrix represents the Transition of Employee which is given in Table 9 Recall that the initial state distribution is R (Table 8). The initial distribution, when multiple by the fundamental matrix, N given Matrix B which is a probability distribution. The row sum equal one. N is the basic manipulation tool for forecasting expected changes in the initial organization of the safety policies.

Employees in the company that is involve in an incident of Near Misses, Unsafe Acts, Unsafe condition and Fire incident has a probability of 0.04 chance of leaving the company through fatality while Employees in the company that is involve in an incident of Near Misses, Unsafe Acts, Unsafe condition and Fire incident as a probability of 0.96 chance to be involved in an incident that will lead to medical treatment. Markov chain model applied in this study has served as both analytical tool and decision support aid that has enabled us to gain insightful perspective of the trends industrial accidents. It is obvious from the analysis that on the average, employees had committed seven near-misses, unsafe acts, unsafe condition or fire incident before actually undergoing real accident or fatality. Employees in the company that is involve in an incident of Near Misses, Unsafe Acts, Unsafe condition and Fire incident as a probability of 0.04 chance of leaving the company through fatality while Employees in the company that is involve in an incident of Near Misses, Unsafe Acts, Unsafe condition and Fire incident as a probability of 0.96 chance to be involved in an incident that will lead to medical treatment.

4.0 CONCLUSION

Data of transitions to and from various states or level in an organization system can be used to develop a Markov Chain Model. Longer periods of observation yield better estimates of transition probability matrix. The Markov Chain Model provided valuable insight into the current safety policies analysis and prediction of the future safety policies of the Generation Company Limited. The studies revealed that employee on the average change position 7 times at each of the transient states before being trapped in any of the absorbing states(Fatality and medical treatment), and Employees in the company that is involve in an incident of Near Misses, Unsafe Acts, Unsafe condition and Fire incident as a probability of 0.04 chance of leaving the company through fatality while Employees in the company that is involve in an incident of Near Misses, Unsafe Acts, Unsafe condition and Fire incident as a probability of 0.96 chance to be involved in an incident that will lead to medical treatment.

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