A Markov Chain Analysis for Estimating the Changes in Crime in Indian Railways

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ABSTRACT

In the present paper we have used the theory of Markov chain for estimating the changes in crime in Indian Railways. Indian Railways is one of the largest railways networks operated by Government of India. Rail transport in India is an important mode of conveyance for people and good. We have defined Markov chain changes in crime in Indian Railways and obtained the transition probability matrix also we have obtained the stationary distribution of the above-mentioned Markov Chain.

Keywords: Stochastic Process, Markov Chain, Transition matrix, Crime, Indian Railways

1. Introduction

Although the stochastic process has been around for decades, Russian mathematician Andrey Markov is credited with popularizing its most important component, the Markov Chain. Numerous disciplines, including chemistry, physics, economics, queuing theory, finance, and the sciences of the body, have used the Markov (1906) chain model. One of the most crucial techniques for applying applied probability theory to real-world models including uncertainty is the use of Markov chains. For the purpose of this study, we employed the Markov chains theory to estimate changes in the crime in railways in India. Numerous authors have employed the Markov chain model extensively in a variety of disciplines, including chemistry, physics, economics, queuing theory, finance, and health sciences, among others. Markov decision models were employed by John & Koutsiumaris (2010) for the treatment of early prostate cancer. The Mean Time to Default of Credit Risky Assets was calculated using a Markov Chain Model with Catastrophe by Dharmara ja, Pasricha, and Tardelli in 2017. Markov Modeling for Breast Cancer was applied by Chunling & Chris in 2009. Doubleday & Esunge (2011) used Markov Chains to analyze the trend of stocks. Murthy & Rao, 2014 employed a Markov Chain model to analyze the behavior of various stock prices for companies. Using Markov Chain characteristics, Mung'atu & Ndanguza, 2017, predicted the amount of rain that would fall in the Gasabo District. Markov Chain modeling has been utilized by Sharma & Adlakha (2014) to investigate gene expression. Markov chain has therefore been utilized in a variety of contexts, but this is the first time we have used it to forecast potential changes in India's crime in railways. Therefore, these concepts inspire us to investigate crime in railways depth.

2. Objective of the Study

The objective of this study is to determine the changes in Crime in Indian Railways for long run.

3. Data Source

For this study we take data from national crime records bureau (NCRB) site from year 2005 to 2016.

4. Study

For the study and mathematical modeling of a certain type of circumstance involving random variables, Markov chains provide the optimal conditions. Markov chains give us straightforward solutions to a variety of complex issues, or we could argue that they supply answers to the biggest issues that affect our environment. Consider a random process x with state space S = 1, 2, 3,..., s and random variables, where x_n denotes the process's state at step n. The study's three states decrement in crime in Indian railways, constancy in in Indian railways, and increase in Indian railways have the potential to change throughout time. If the future state depends only on the current state and not on the past, the process is referred to as a Markov Chain. Mathematically,

$$P(x_{n+1} = \mathrm{j}|x_n = \mathrm{i}, x_{n-1} = i_1, x_{n-2} = i_2, x_{n-3} = i_3, \dots, x_0 = i_n) = P(x_{n+1} = \mathrm{j}|x_n = \mathrm{i}) \quad (4.1)$$

For every sequence $i_1, i_2, \dots, i_n$ of elements of S and every $n \geq 0$. The probability transition matrix

$$P_{ij} = P(x_{n+1} = \mathrm{j}|x_n = \mathrm{i}) \quad (4.2)$$

Is defined as the probability that whenever the chain in state i it moves to state j in one step. A transition probability matrix P considering of all the transition probabilities between stages in a matrix form is given by:

$$P = \begin{bmatrix} p_{11} & \cdots & p_{1s} \\ \vdots & \ddots & \vdots \\ p_{s1} & \cdots & p_{ss} \end{bmatrix}$$

Let F_R be the transition frequency matrix for crime in Railways.

5.1 A Markov Chain analysis for estimating the changes in crime in Indian Railways

From our data these are obtained as follows:

$$F_R = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 0 & 2 \\ 0 & 1 & 5 \end{bmatrix}$$

The frequency matrix may be converted into probability matrix by using formula

$$P_{ij} = \frac{a_{ij}}{\sum a_{ij}} \quad (5.1.1)$$

Where,

i = Rows and

i = Columns

(i, j) = 1, 2, 3

Let P_R be the transition probability matrix for crime in Railways.

Hence

$$P_R = \begin{bmatrix} 0.67 & 0.33 & 0 \\ 0.33 & 0 & 0.67 \\ 0 & 0.16 & 0.84 \end{bmatrix}$$

From the aforementioned transition probability matrices, we deduced that the transition from state 1 to state 1 has the highest probability i.e., 0.84, this indicates that crime in Railways have a high probability with a growing tendency.

5.2 Stationary Distribution or the Limiting Probability Distribution

Since transition probability matrix are irreducible and aperiodic in nature and hence all states are non-null recurrent. Therefore, this matrix is ergodic in nature. So we have obtained their stationary (Steady State) distribution by using formula

$$\pi = \pi P$$

Where $\pi = [\pi_{-1}, \pi_0, \pi_{+1}]$ and P be the transition probability matrix. Therefore

$$\pi = [\pi_{-1}, \pi_0, \pi_{+1}] \begin{bmatrix} 0.162 & 0.162 & 0.676 \\ 0.162 & 0.162 & 0.676 \\ 0.162 & 0.162 & 0.676 \end{bmatrix} = [0.267, 0.122, 0.611]$$

6. Results and Conclusions

In order to draw the conclusion that there is a high likelihood of an increase in crime in railways in the future, we looked at the stationary probability matrix for crime in Indian Railways and found that the probability of a decrease in crime there is 26 percent, the probability that it will stay the same is 12 percent, and the probability of an increase in crime there is 62 percent.

7. Funding Source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

8. Acknowledgement

We are extremely grateful to Prof. R.K. Singh for their invaluable assistance and support.

9. Decelerations of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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