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QUALITY ANALYSIS IN THE MANUFACTURING INDUSTRY BY USING MARKOV CHAIN METHOD

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Abstract

Quality control is a vital role for the development of an effective business to meet customer delight. In production, quality control is a growth that secure customers accept products free from shortage and meet their needs. When done the wrong way, it can put consumers at risk. It helps quality administrators analyze and solve complications before products quit the facility. Six steps to developing a quality control process are: setting the quality criterion and deciding which quality level to focus on; reducing running processes to deliver quality; surveying your results; getting feedback and making enhancement. In this paper, we are concentrating on the quality level in the production industry and the consideration between the two types of Maruti products using simplex methods in operational research and finding the maximum optimum solution. From the maximum optimum solution, we can get the quality rate of the product by using the Markov chain method and further applying data in Minitab software to examine the quality of the product in the graphical method.

Keywords : Maruti Suzuki Alto variant, Simplex method, Markov Chain method, Minitab software.

1. Introduction

Customer satisfaction determines the success of a new product, and only products of high value meet the needs of clients who expect them to perform correctly throughout their whole life cycle. In order to fulfil such requirements, a minimum variation of parameters should be assured within the manufacturing processes and the product itself. From the most basic to the most complex parts, they must be designed and manufactured to a high standard of quality, and they must be reliable and safe to use.When we study a system that can change over time, we need a way to keep track of those changes. A Markov chain or Markov process is a stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event. A countable infinite sequence, in which the chain moves state at discrete time steps, gives a discrete time Markov chain. A continuous time process is called a continuous time Markov chain. It is the method of analysis by which management receives aid for their decisions. Though the name of this method, Operation Research, is relatively new, the method used for this is not a new one. Operation research is concerned with the application of the principles and methods of science to the problems of strategy. In 1924, Walter A. Shewhart [1] of the Bell Telephone Laboratories laid the foundation for statistical quality control. Since then, the area of SQC has been enriched by the work of numerous statisticians, quality philosophers, and researchers. Muwafaq Alkubaisi (Muwafaq Alkubaisi) [2] Six Sigma was used to create an X-bar chart from data collected from a petroleum company in Kuwait.Unfortunately, it seems there are some serious deficiencies in the production process since the values of Cp and Cpk are less than 1, which means the process is not capable of meeting its specifications. Muhammad Muazzem Hossain et al. [3] the concept of statistical quality control has emerged as a scientific revolution in the arena of quality control and that the discipline of statistical quality control has its own research tradition. Terna Godfrey Leren et al. [4] apply statistical control charts in monitoring the production, packaging, and distribution or marketing processes of sachet water in Nigeria. Michael Stuart et al. [5] statistical analysis and methods' contributions to modern quality control and improvement.Jong Min Kim et al. [6] A residual (r) control chart of asymmetrical and non-normal binary response variables is proposed in this research. Hassen Muttlak et al. [7] Different quality control charts for the sample mean are developed using ranked set sampling (RSS) and two of its modifications, namely median ranked set sampling (MRSS) and extreme ranked set sampling (ERSS). Kai Yang

et al. [8] is an extension of Neuhardt's work which questions the typical assumption that the subsamples used to establish statistical process control charts are uncorrelated. Lonnie C. Vance A search of the literature to determine the status of statistical quality control chart techniques for the years 1970–1980 was conducted. Azizah et al. [10] demonstrate an application of the Markov chain using a data mining approach to get the knowledge as a pattern for description and prediction. R.Arumugam et.al (2020) [11] explained the prediction of COVID-19 in India based on the Markov model. E.Preethi et. al (2017) [12] discussed the applications of stochastic model in the Webpage ranking. The prominent contributors include Zichang He and Wen Jiang. [13] The new Berief Markov chain model overcomes the shortcomings of the classical Markov chain and has an efficient ability to deal with uncertain information. V.O. Ezugwu et al. [14] The use of mathematical models for manpower planning has increased in recent times for better manpower planning quantitatively. Soren Asmussen et al. [15] consider GI/G/I queues in an environment that is periodic in the sense that the service time of the nth customer and the next interarrival time depend on the phase at the arrival instant. Ping-Qi Pan [16] For an optimal solution, a dual crash heuristic is described to produce an initial "good" basis. V. Sangeetha et al. [17] developed a strong ranking technique for the iterative values of the trapezoidal fuzzy numbers within the fuzzy transportation problem. Nebojsa V. Stojkovic, et al. [18] the significance of the simplex algorithm's starting pointW. H. Cunningham [19] relates to a new perturbation technique and to previously known degeneracy modifications for shortest path problems and maximum flow problems. Based on the statistical study, Dr.R.Arumugam et al. [20] the impact of dengue fever in Thanjavur district is based on the data.

2. **Methodology**

The data was collected from the following websites: https://www.cardekho.com/maruti/maruti-alto-800-2016-2019-specifications.htm and https://zoutons.com/news/maruti-suzuki-alto-800-review. To find the best optimum solution, the data were entered into the simplex method in Operation Research. While comparing the optimum solution; we have got the best model of the Maruti Suzuki Alto 800 and Alto K10. Furthermore, we will use the best model in the Markov chain method to find the transition matrix and solution of the Markov chain. After finding the Markov chain solution, we will put the data into Minitab software to check the quality rate of the Maruti Suzuki Alto 800. Then, finally, we will check the results and give the conclusion.

3. Mathematical Model

3.1 Simplex method

The Maruti Suzuki brand produces many types of Maruti products. Here we will take only two types of products, namely the Maruti Suzuki Alto 800 and the Maruti Suzuki Alto K10. The displacement of these two products, Alto 800 and Alto K10, is 796 cc and 998 cc, respectively. The max power of the Alto 800 and Alto K10 is 47 bhp @ 6000 rpm and 67 bhp @ 6000 rpm, respectively. The max torque of the Alto 800 and K10 is 69 Nm at 3500 rpm and 90 Nm at 3500 rpm, respectively. Then the profit of Alto 800 is 20,000 per car and the profit of Alto K10 is 24,000 per car. From the above information, we could write the objective function and constraint equation.

Objective function

$$20{,}000\,x + 24{,}000\,y = Max\,z$$

Subject to the Constraint

$$796\,x + 47\,y \le 69$$

$$998\,x + 67\,y \le 90, \qquad \forall x, y \ge 0$$

After applying the slack variables s_1, s_2 to equal the inequality, we get

Objective function

$$Max\,z = 20{,}000\,x + 24{,}000\,y + 0\,s_1 + 0s_2$$

Subject to the constraints

$$796\,x + 47\,y + s_1 = 69$$

$$998\,x + 67\,y + s_2 = 90 \qquad \forall\, x, y, s_1, s_2 \ge 0$$

Table 1 Initial Iteration

CB_i	C_j	20,000	24,000	0	0	Solution	ratio
	Basic variable	x	y	s_1	s_2		
0	s_1	796	47	1	0	69	1.468
0	s_2	998	67	0	1	90	1.343
	z_j	0	0	0	0		
	$c_j - z_j$	20,000	24,000	0	0		

Table 2 First Iteration

CB_i	C_j	20,000	24,000	0	0	Solution	Ratio
	Basic variable	x	y	s_1	s_2		
24,000	y	16.936	1	0.021	0	1.468	0.087
0	s_2	-136.72	0	-1.425	1	-8.36	0.059
	z_j	406464	24,000	0.504	0		
	$c_j - z_j$	-386464	0	-0.504	0		

Here, all the $c_j - z_j \leq 0$. Then x = 0 and y = 1.468, satisfying the first constraint, 796(0) + 47(1.468) = 68.9 = 69, and providing an optimal solution, Max z = 35,232.By the definition of an optimum solution, "an optimal solution is a feasible solution where the objective function reaches its maximum value." By the Simplex method, an optimal solution attains its maximum value of 35232 and, by constraint equation; we assume that the best model is the Maruti Suzuki Alto 800.

3.2 Markov chain model

"A Markov chain or Markov process is a stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event." Consider the Stochastic process $\{x_n;\ n = 0,1,2.....\}$ the possible value for $x_n = i \in S$ where S is a state space and S is finite or countable.

By the definition the one step transition probability can be written as $P_{ij} = P\{x_{k+1} = j / x_k = i\}$. Similarly the n step transition matrix can be written as $P_{ij} = P\{x_{k+n} = j / x_k = i\}$.

From the simplex method, I decided to take the Alto 800. For my assumptions, I have taken the 2019 and 2020 models of the Alto 800. In the Alto 800 model specifications, the data is classified into three modes: engine and transmission, fuel and performance, and dimensions and capacity.

Based on fig. 1.1, I assumed the sum of the same value and different value for both the 2019 and 2020 models is one.

The three-step transition probability can be written as

$P_{ij}^{3} = P\{x_{k+2} = j / x_k = i\}$, for i and j we assume same and different so we can written as

$P_{ij}^{3} = P\{x_{k+2} = j / x_k = i\} = P\{x_{k+2} = S / x_k = D\}$ .....(1)

We can using the formula $P\{A/B\} = P\{A \cap E/B\} + P\{A \cap E^c/B\}$ in equation number (1), we get

$P\{x_{k+2} = S / x_k = D\} = P\{x_{k+2} = S, x_{k+1} = S / x_k = D\} + P\{x_{k+2} = S, x_{k+1} = D / x_k = D\}$.....(2)

We can applying conditional probability $P\{AE/B\} = P\{A/EB\}P\{E/B\}$ In equation number (2), we get

$$(2) \Rightarrow P\{x_{k+2} = S / x_k = D\}$$
$$= P\{x_{k+2} = S / x_{k+1} = S, x_k = D\}P\{x_{k+1} = S / x_k = D\} + P\{x_{k+2} = S / x_{k+1} = D, x_k = D\}P\{x_{k+1} = D / x_k = D\}$$
$$= P\{x_{k+2} = S / x_{k+1} = S\}P\{x_{k+1} = S / x_k = D\} + P\{x_{k+2} = S / x_{k+1} = D\}P\{x_{k+1} = D / x_k = D\}$$
= (1.2)(1) + (1.2)(1)
=2. 4

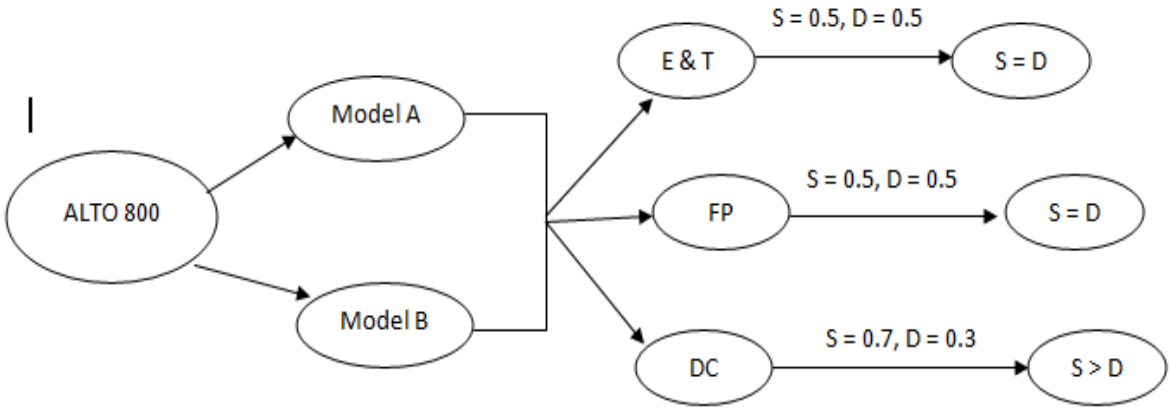

Fig 1.1

Fig 1.1 describes the two models of Alto 800 and their three specifications. engine and transmissions, fuel performance, dimensions and capacity. Here I have assumed the sum of the values of the same features and different features is equal to one. Further, I have split the values and given the same and different features. The same and different features are the same in engines and transmissions; the same and different features are the same in fuel performance; and the same features are greater than the different features in dimension and capacity.

From the fig 1.1 the transition matrix can be written as

$$P = \begin{bmatrix} 0.5 & 0 & 0.5 \\ 0.5 & 0.5 & 0 \\ 0 & 0.7 & 0.3 \end{bmatrix}$$

The transition matrix $P_{ij} = 1$. Therefore, this satisfies the Markov chain condition.

3.3 Control chart

The control chart is a graph used to study how a process changes over time. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. Control charts for variable data are used in pairs. The control chart measures the performance and continuous monitoring of the process. The control charts are prepared with the help of Minitab software. Test values that fall within the specified range are considered acceptable, and those that fall outside are considered defects. In the control chart below, values that are outside of the control limits are shown in red, while values that are within the control limits are shown in blue. The control charts are as follows:

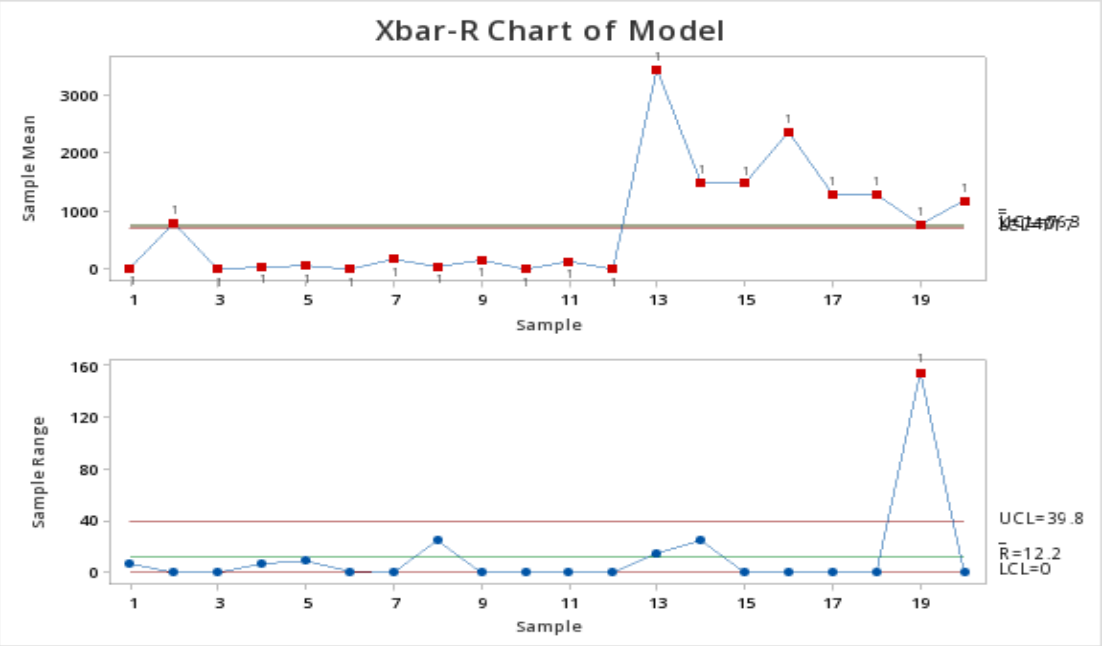

Figure 2: X bare and R-chart

4. Discussion and Results

In the mathematical model, I have just explained the Simplex method and the Markov chain model. In the simplex method, I have taken two models of Maruti Suzuki, the Alto 800 and the K10. Using the displacement, max power, max torque, and profit of these two models, I have found the objective function and subject to the constraints. Then I just added the two slack variables s_1, s_2 to equal the inequality constraints and also add these slack variables into the objective function. Then, using this objective function and constraints, I have just applied the simplex method. In the first iteration table, all $C_j - Z_j \geq 0$ but for this maximised objective function all $C_j - Z_j \leq 0$. So further, we have to go to iteration table 2 there all $C_j - Z_j \leq 0$ and find the values of x = 0 and y = 1.468. Applying x and y values in the constraint equations satisfies the first constraint equation and the optimal solution of Max z = 35232. From this simplex function, I have chosen Alto 800 for further procedure because, while using the values of x and y, it satisfies the first constraint equation, which represents the Alto 800 model. Then I compared the 2019 and 2020 models of the Alto 800. The information was divided into three categories: engine and transmission performance, fuel performance, and specification dimension and capacity.Using these three specifications, find the three-step transition probability and transition matrix. The value of the transition probability is 2.4 and the transition matrix of all the rows is equal to 1. Then fig 1.1 explains the two models' same and different specifications. Then, using data from the 2019 and 2020 Alto 800 models, create control charts.By using Minitab software, the X bar and R charts are plotted. By using the three important tests of control chart in Minitab software, they are 1 point > K standard deviations from the centre line, K points in a row on the same side of the centre line, and K points in a row within 1 standard deviation of the centre line, and finding the quality rate in the graphical representation. There, the values that lie inside of the control limit are denoted as blue dots, and the values that lie outside of the control limit are denoted as red dots. Test result for X bar chart, test 1: one point more than 3.00 standard deviations from the centre line. The test failed at points 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20. Test 2: 9 points in a row on the same side of the centre line. At points 11 and 12, the test failed. Test result for R chart, test 1: one point more than 3.00 standard deviation from the centre line, test failed at point 19.

5. Conclusion

This paper describes the quality level in the car manufacturing industry by using the simplex method, the Markov chain method, and Minitab software. In the simplex method, we compare two types of Maruti Suzuki models and find the optimal solution, deciding to proceed with the model Alto 800 for the further procedures. Then I just compare the 2019 and 2020 models of Alto 800 in the Markov chain method and find the transition probability value and transition matrix. Then further, the data was used in the Minitab software to find the quality rate of the Alto 800 model by the graphical representation. In the X bar chart, all the values are outside of the control limit, and in the R chart, all the values are inside the control limit except for one point. In the R chart, we can say the data has no defects or it has a very low rate of defects.

References

1. Shewhart, W.A.(1926), Quality Control Charts, Bell System Technical Journal, Vol 5, Issue 4, Pages 593-603.
2. Muwafaq Alkubaisi, 2013 Statistical Quality Control (SQC) and Six Sigma methodology: An Application of X-bar chart on Kuwait Petroleum Company, " International Journal of Business Administration, Sciedu press, Vol. 4(3), pages 61-72, May.
3. Muhammad Muazzem Hossain, Victor R. Prybutok, A.B.M. Abdullah, Majharul Talukder, 2010 The development and Research Tradition of Statistical Quality Control, International Journal of Productivity and Quality Management, Vol 5, No 1.
4. Terna Godfrey Leren, Samson Kuje, Abraham Lorkaa Asongo, Innocent Boyle Eraikhuemen, 24 Nov 2020 " Application of Statistical Quality Control in Monitoring the Production, Packaging and Marketing Process of Sachet Water", Journal of Scientific Research and Reports, Pages 32-45.
5. Michael Stuart, Eamonn Mullins, Eileen Drew, 20 Jan 1996 " Statistical Quality Control and Improvement", European Journal of Operation Research, Vol 88, Issue 2, Pages 203-214.
6. Jong Min Kim, ll Do Ha, 31 July 2021, " Deep Learning – Based Residual Control Chart for Binary Response", New Advances and Applications in Statistical Quality Control, 13(8).
7. Hassen Muttlak, Walid Al – Sabah, 2 Aug 2010, " Statistical Quality Control Based on Ranked Set Sampling", Journal of Applied Statistics, Vol 30, Issue 30, Pages 1055- 1078.
8. Kai Yang, Walton M. Hancock, Mar 1990, " Statistical Quality Control for Correlated Samples", International Journal of Production Research, 23(8), 595-608.
9. Lonnie C. Vance, 22 Feb 2018, " A Bibliography of Statistical Quality Control Chart Techniques, 1970-1980" Journal of Quality Technology, Vol 15, Issue 2, Pages 59-62.
10. A Azizah, R Welastika, A Nur Falah, B N Ruchjana and A S Abdullah, " An Application of Markov Chain for Predicting Rainfall data at West Java Using Data Mining Approach", IOP Conference series: Earth and Environment science, Vol 303, International Conference on Tropical Meteorology and Atmospheric Sciences 19-20, Sep 2018, Citation A Azizah et al 2019 IOP Conf, Ser: Earth Environ. Sci. 303 012026.
11. Dr. R.Arumugam, M.Rajathi, 2020 " A Markov Model for Prediction of Corona Virus COVID-19 in India- A Statistical Study", Journal of Xidian UniversityVol.14, Issue 4, April 2020, Page No 1422-1426
12. E. Preethi, Dr.R.Arumugam, (2017), "Applications of Stochastic Models in Web Pageranking", - International Journal of Recent Trends in Engineering and Research (IJRTER), Vol.3, Issue 3, March 2017, Page No. 245-252.
13. Zichang He & Wen Jiang (2017): " A New Belief Markov Chain Model and Its Application in Inventory Prediction, " International Journal of Production Research, DOI: 10.1080/002075 43.2017.1405166.
14. V.O. Ezugwu, S Ologun, 2017, " Markov Chain: A predictive Model for Manpower Learning", Journal of Applied Sciences and Environmental Management, Vol 21, No.3(2017).
15. Soren Asmussen and Hermann Thorisson, " A Markov Chain Approach to Periodic Queues", Journal of Applied Probability, Vol. 24, No 1 (Mar., 1987), pp. 215-225.
16. Ping-Qi Pan, (1998), " A Dual Projective Simplex Method for Linear Programming", Computers & Mathematics with Applications, Volume 35, Issue 6, Pages 119-135.
17. Sangeetha, V., Thirisangu, K, Elumalai, P, " Dual Simplex Method based Solution for Fuzzy Transportation Problem", Journal of Physics, Vol 1947, Issue 1.
18. Nebojsa V. Stojkovic, Predrag S, Stanimirovic, Marko D. Petkovic, and Danka S, 2012, " On the Simplex Algorithm Initializing", Vol 2012.
19. W. H. Cunningham, Dec 1976, " A Network Simplex Method", Mathematical Programming 11, 105-116.

20. Dr. R. Arumugam, C. Gowri, M. Rajathi (2019), A Statistical study on Impact of Dengue fever in Thanjavur District the usage of SPSS, Compliance Engineering, Vol. 10, Issue 12, PP 245-252.