Warranty Cost Estimation using K-Means Cluster Analysis for Automobile Industry: Technical Note

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ABSTRACT:

When a vehicle under warranty comes for service, the technician identifies the potential fault and the corresponding service is done. From the raw information of customer complaint, the complaint codes are identified and allocation of qualified technician involves considerable man hours and cost per hour for the technician to do the service. Around 1059 vehicles under warranty were studied starting from customer complaint to the study of warranty cost to the manufacturer. In this paper, initially, we present the results of classifying the complaint code master into several classes using K-means cluster analysis and subsequently cluster analysis for a specific component say, water pump assembly was carried out. Then, analysis of cost to the automobile manufacturer on warranty claims are also presented.

KEYWORDS:

Automobile; Cluster; Warranty; Estimation; Cost Analysis

1. Introduction

Warranty provides a free replacement for any component which fails or proves defective during normal use on the vehicle on which it was originally installed. A replacement for a failed or defective component should be made available from the point of purchase. There are multiple techniques to detect credit card fraud like Neural Network, Group Method of Data Handling, Bagging [1-3]. But none of the techniques have been reported for warranty claim in automobile industry warranty claim. Karim et al [4] analysis presented an excellent review paper that summarizes the different statistical models and methods used to analyse warranty claims data. Wu [5] presented a new approach on warranty data analysis. Warranty data might be aggregated into groups. Different parties (sales people, information processing team, service agents) might provide different types of aggregated data [6, 7].

A review of different data mining techniques for fleet industry [8] and modelling an optimized warranty analysis methodology for fleet industry using data mining clustering methodologies with fraud detection mechanism using pattern recognition has been studied [9]. The replacement of the unit is the only remedy for the claims of any type arising from the failure or defective condition. Hence, a reliability and survival analysis of the components is essential in the automobile industry. The sample warranty claim sheet is given in Fig. 1. Around 7 types vehicles belonging to Indian automobile industry, in which water pump assembly

failure was observed during the period of study were considered for the study. A count of 1059 vehicles returned to the manufacturer in 3 years' observation period for the replacement of water pump assembly. This cost is referred to as the warranty cost and it depends on several factors, with product reliability being one of the very important ones. Sample of complaint master data sheet for water pump failures is shown in Table 1.

Fig. 1: Sample warranty claim sheet for water pump assembly

Table 1: Sample of complaint master data for water pump failures

Job code	Job description	Man hour	Cost /hr. (Rs)
200009	Water pump repair	1.5	120
200008	Water pump removal & installation (w/t)	4	320
610144	Water leakage repair through wind shield beading (apply sealant)	1	80
610149	Water leakage repair from wheel arch to floor joint (apply sealant)	0.25	20
610150	Water leakage repair from roof marker lamp (apply sealant)	0.25	20
610152	Water entry through air snorkel joint - re self (apply sealant)	0	0

2. Analysis model and results of overall complaint master

Analysing the overall set of 58235 complaint codes shows the descriptive statistics as given in Table 2. Application of k-means cluster analysis has classified into 5 clusters, based on man-hours and wages/hour for complaint rectification. The partition clusters are listed in Table 3. Final cluster centroids are listed in Table 5. Table 4 illustrates that out of a total of 58235 complaints studied, majority (around 52271) complaint codes fall under cluster 5, which consumes a mean of 0.9745 man hours and average cost/hr. at Rs.77.96.

Table 2: Statistical summary of complaint master

Variable	N	N*	Mean	Min.	Max.
Man hrs	58235	0	1.9252	0.0000	77.6000
Wages @ Rs.80/hr	58235	0	154.02	0.00	6208.00

Table 3: Final partition

Cluster	No. of observations	Within cluster sum of squares	Avr. dist. from centroid	Max. dist. from centroid
1	4580	8.51225×10^7	112.777	377.242
2	873	7.7263×10^7	242.319	665.012
3	259	3.33968×10^7	323.555	685.768
4	252	1.08391×10^7	553.178	1661.495
5	52271	1.84968×10^7	45.715	170.052

Table 4: Cluster centroids

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Man hrs	5.2848	15.688	34.5714	56.8329	0.9745
Wage @ Rs.80/hr	422.79	1255.04	2765.71	4546.63	77.96

Table 5: Distances between cluster centroids

Cluster	1	2	3	4	5
1	0.00	832.32	2343.11	4124.17	344.85
2	832.32	0.00	1510.79	3291.85	1177.17
3	2343.11	1510.79	0.00	1781.06	2687.96
4	4124.17	3291.85	1781.06	0.00	4469.02
5	344.85	1177.17	2687.96	4469.02	0.00

3. Analysis model and results of water pump assembly complaint

Cluster analysis partitions for the water pump assembly warranty data set are given in Table 6 and corresponding cluster centroids is given in Table 7. It can be inferred that around 592 complaints (cluster 2) takes an average of 1.02 man hours and costs around Rs.81.6014.

Table 6: Final partition for water pump assembly

Cluster	No. of observations	Within cluster sum of squares	Avr. dist. from centroid	Max. dist. from centroid
1	79	34678.835	20.460	58.739
2	592	354041.229	14.314	78.405
3	363	33713.256	9.287	12.673
4	25	0.000	0.000	0.000
5	0	0.000	0.000	0.000

Table 7: Cluster centroids for water pump assembly dataset

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Grand centroid
Man hrs	3.73	1.02	0.34	0.00	0.00	0.97
Wages @ Rs.80/hr	298.73	81.60	27.33	0.00	0.00	77.27

4. Warranty cost analysis

It is evident from Table 8 that approximately 1022 man hours have been spent on replacement of water pump assembly in a period of 3 years observation for about 1059 vehicles and a sum of Rs. 81,828 is spent on wages of the technician at Rs. 80/hour. This additionally includes cost of replacement of the water pump assembly around Rs. 1,800 per vehicle which is around Rs. 19,06,200. Thus total cost of warranty replacement is sum of the product replacement and amount spent on wages for service.

Table 8: Statistics of water pump replacements under warranty

Variable	N	Mean	Min.	Max.
Man hrs	1059	0.9659	0.00.	4.00.
Wages @ Rs.80/hr	1059	77.27	0.00	320.00

5. Summary

This warranty cost analysis for water pump assembly applies for all components specified in master complaint codes. Hence, the total cost to the manufacturer would be very high. Thus, it is essential to understand the importance of warranty cost spent to a roadmap of failures and overall quality of the product can be created based on this information. This data can also assist in evaluating past reserve levels and forecasting expenses related to future populations.

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