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Warranty Analysis: A Non-Parametric Approach

Mr. Madan M. Jagtap
Saraswati College of Engineering,Kharghar,Navi Mumbai,India
&
Prof. S.N.Teli
Saraswati College of Engineering,Kharghar,Navi Mumbai,India
&
Dr. U.M.Bhushi
Sahyadri College of Engineering and Management,Manglore,Karnataka,India

Abstract:
Present work is to implement Non-Parametric Approach to warranty. Basic idea is while servicing product in warranty period against claim of customer, recording data for claim and frequency of claim helps in finding major problem in product.First time failure data available with dealers for consecutive five months which can be consider as data set for warranty analysis. Repair per thousand(R/1000), cumulative hazard rate and cost per unit (CPU) compares Month in service (MIS) of product for each manufacturing month, can be considered as non-parametric analysis of warranty data. It helps in finding variation product failure and cost related with it.

Keywords: Repair per thousand(R/1000), Cost per unit (CPU), Month in Service (MIS), Warranty, Non parametric

Introduction:

An automobile which comprises over 7000 parts is a highly complicated product. Employing the best quality and reliability practices during product development, manufacturing, and assembly is desirable, unexpected failures during the warranty period do occur and it cost automobile companies billions of rupees annually in warranties. Warranty cost reduction programs in these Industries have high priority. Various teams in Industry work together to achieve objectively defined targets for warranty cost reduction that are often based on the warranty claims of the previous model-year vehicles,Due to readily accessible data from the limited numberof vehicles in the fleet, the modelling and analysis of such data does not pose aserious problem. However, in automotive companies, access to field data is mainlythrough warranty data. Hence, designers and engineers working on current and forwardmodel vehicles also look forward to warranty data for more accurate feedbackon design.Murthy and Djamaludin (2002) note that the decisions and actions during design,manufacturing, and assembly determine the inherent reliability of the product.

Methodology:

Data Analysis

In order to obtain meaningful and effective results, data analysis must be done at three different levels and must be carried out by an analyst with a strong background in statistics and a good understanding of the warranty process. The three different levels of analysis are

Level 1

Customer complaints are usually in text format. Text mining approaches provide a methodology for identification and classification of the problems expressed in the complaints. It is not uncommon to find that a customer reports a problem, but the service agent is unable to *find* any fault.

Level 2

This can involve several stages. The first stage involves looking at failures at the product level by pooling the data without differentiating MOP, MIS,and carrying out a Pareto analysis based on failed components and/or failure mode. These analyses give an indication of which components are weak (with low reliability) and identify the dominant failure modes. The second stage involves plotting failure data at the product level by grouping the data based on MOP, MIS, or other factors, without differentiating by defect code. These results are used to prepare plots such as time series plot, with time being linked to MOP, MIS-MOP plots, etc. The aim of these analyses is to detect sudden changes or noticeable trends, which may be indicators of a problem. The third stage is to carry out an analysis similar to that in Stage 2, but in a more detailed manner, for example, for each different defect code or any other meaningful classification. Problem Detection The detection of a problem is based on specified rules for detection, which are often similar to the rules used for detecting quality variation based on control

Any detection rule suffers from the following two types of errors:

- Type 1 error: The rule indicates no problem when there is an underlying problem
- Type 2 error: The rule indicates that there is a problem when there is none

These errors occur mainly because of limited data and the resulting uncertainties associated with small samples.

Level 3

There are two different types analysis at Level 3. The first is a detailed analysis of failed components carried out by in-house or external experts to better understand the causes of the various types of failures. This requires understanding the mechanism of failure and the factors that influence the failure (for example, material used, vendor, and design). The second is to link component failure to various operations in different phases of the product life cycle (such as design approach used, quality control in production, etc.). In either case, information atthe detailed level is required, and the tools used for detecting the problem more complex.

Problem Detection

Customer Related Problems

The primary data for detecting customer related problems are (1) The data collected by the service agents from customers when a warranty claim is initiated, and (2) Through customer surveys. Upward trends in the numbers of customers who are not satisfied with product performance and/or warranty service provided indicate needs and opportunities for improvement.

Service Related Problems

The primary data for detecting service related problems are customer complaints relating to warranty servicing and claims for reimbursement. For optimal impact, the analysis of data of this type must be done for each service agent in detail, Information needed includes labor cost, service time for different labor or defect codes, and other important measures, many of which are product specific. Service agents are then compared to determine if some have significantly higher or lower values. Significant differences indicate that there is a service-agent-relatedproblem.

Production Related Problems

The primary data in this area are those relating to the servicing of failed units provided by the service agents. The data is obtained from the production department and from component vendors. The data must allow a failed component to be traced to the month of production or batch number, and the component manufacturer, which may be either the product manufacturer or an external vendor.

Design Related Problems

The primary source of data regarding design aspects is the detailed analysis carried out at Level 3. The purpose of the analysis is to understand the failure mechanism and the design flaws that failed to take this mechanism into account.Table 1 shows problem with level of analysis.

Table 1 Problem Type and Level of Analysis

Problem	Level of Analysis
Customer	Level 1
Service Agent and Production	Level 1 and 2
Production and Design	Level 1,2 and 3

Non-Parametric Data Analysis

Data analysis begins with the use of graphical and analytical approaches in orderto gain insights and draw inferences without making any assumptions regardingthe mathematical formulation that is appropriate for modelling the data.Nonparametric methods play an important role in this approach to the analysis ofdata. They provide an intermediate step toward building more structured modelsthat allow for more precise inferences with a degree of assurance that the modelassumptions are valid. As such, nonparametric methods are also referred to asdistribution-free methods.

The nonparametric approach allows the user to analyse data without assuming an underlying distribution. That is, the approach does not require that the form of the sampled population be known. The nonparametric approach has a number of advantages as well as some inherent disadvantages. The ability to analyse data without assuming an underlying life distribution avoids many potential errors that may occur because of incorrect assumptions regarding the distribution. On the other hand, the use of nonparametric procedures with data that can be handled with a parametric procedure is inefficient in the sense that it results in loss of information.In particular, the confidence bounds associated with the nonparametric approach are usually wider than those calculated via the parametric approach, and predictions outside the range of the observations are usually not possible. It is recommended that any set of warranty data first be subjected to a nonparametric analysis before moving on to parametric analyses based on the assumption of a specific underlying distribution.

The nonparametric approach to inferences regarding quantities such as the distribution function F(t), density function f(t), reliability function R(t), hazard function h(t), cumulative hazard function H(t), renewal function M(t), mean cumulative function (MCF) l(t), as well as warranty claim rates (WCR) at the product, component or some intermediate level.These quantities may be used to estimate and forecast future warranty costs. For example, estimates of M(t) are needed for estimation of warranty costs for the non-renewing FRW policy where failed items are replaced by new, and of l(t) when failed items are rectified through minimal repair.

For an Automobile industry Non-parametric analysis is done using hazard rate, repairs per thousand, and cost per unit. Table 2, below explains changes in hazard rate, repairs per thousand and cost per unit for a product with its month of production and successive month in service, Tables given shows for months September, October, November, December and January as month of production gives changes with month in service for hazard rate, repairs per thousand and cost per unit.

Table 2 warranty claim data for successive MOP

Warranty Claim data for MOP-September							
MIS	**Number of Claims**	**Number of Vehicles in Field**	**N(t)**	**h(t)**	**H(t)**	**R/1000**	**CPU**
4	4	8640	8640	0.00046	0.00046	0.46	5.106
5	9	8640	8636	0.00104	0.0015	1.5	16.65
6	2	8640	8627	0.00023	0.00173	1.73	19.203
8	5	8640	8625	0.00058	0.00231	2.31	25.641
10	6	8640	8620	0.00069	0.003	3	33.3
12	1	8640	8614	0.00012	0.00312	3.12	34.632
Warranty Claim data for MOP-October							
3	8	10259	10259	0.00078	0.00078	0.78	8.658
4	8	10259	10251	0.00078	0.00156	1.56	17.316
5	13	10259	10243	0.00127	0.00283	2.83	31.413
6	12	10259	10230	0.00117	0.004	4	44.4
7	30	10259	10218	0.00293	0.00693	6.93	76.923
9	23	10259	10188	0.00225	0.00918	9.18	101.898
10	21	10259	10165	0.00206	0.01124	11.24	124.764

11	10	10259	10144	0.00098	0.01222	12.22	135.642
Warranty Claim data for MOP-November							
1	3	8812	8812	0.00034	0.00034	0.34	3.774
2	5	8812	8809	0.00057	0.00091	0.91	10.101
3	4	8812	8804	0.00045	0.00136	1.36	15.096
4	6	8812	8800	0.00068	0.00204	2.04	22.644
5	6	8812	8794	0.00068	0.00272	2.72	30.192
6	18	8812	8788	0.00204	0.00476	4.76	52.836
8	20	8812	8770	0.00228	0.00704	7.04	78.144
9	16	8812	8750	0.00182	0.00886	8.86	98.346
10	14	8812	8734	0.0016	0.01046	10.46	116.106
Warranty Claim data for MOP-December							
0	1	11009	11009	0.00009	0.00009	0.09	0.999
1	2	11009	11008	0.00018	0.00027	0.27	2.997
2	1	11009	11006	0.00009	0.00036	0.36	3.996
3	2	11009	11005	0.00018	0.00054	0.54	5.994
4	6	11009	11003	0.00054	0.00108	1.08	11.988
5	19	11009	10997	0.00172	0.0028	2.8	31.08
7	31	11009	10978	0.00282	0.00562	5.62	62.382
8	26	11009	10947	0.00237	0.00799	7.99	88.689
9	12	11009	10921	0.0011	0.00909	9.09	100.899
Warranty Claim data for MOP-January							
3	1	11566	11566	0.00008	0.00008	0.08	0.888
4	4	11566	11565	0.00034	0.00042	0.42	4.662
6	4	11566	11561	0.00034	0.00076	0.76	8.436
7	3	11566	11557	0.00026	0.00102	1.02	11.322
8	1	11566	11554	0.00008	0.0011	1.1	12.21

Results:

Table 3 shows end values of hazard rate, repairs per thousand and cost per unit for each month of production.

Table 3 Hazard rate H(t), Cost per Unit and Repair per 1000 data for successive Months

Month of Manufacture	H(t)	CPU	R/1000
October	0.01222	135.642	12.22
November	0.01046	116.106	10.46
December	0.00909	100.899	9.09
January	0.00110	12.21	1.10

For Studying variations with month in service, Table A1(data taken from appendix) explains variation of cumulative hazard rate for month of production with successive month in service,for successive month in service hazard rate increases as month in service increases and afterwards it decreases, Figure 3 is to show variations graphically.

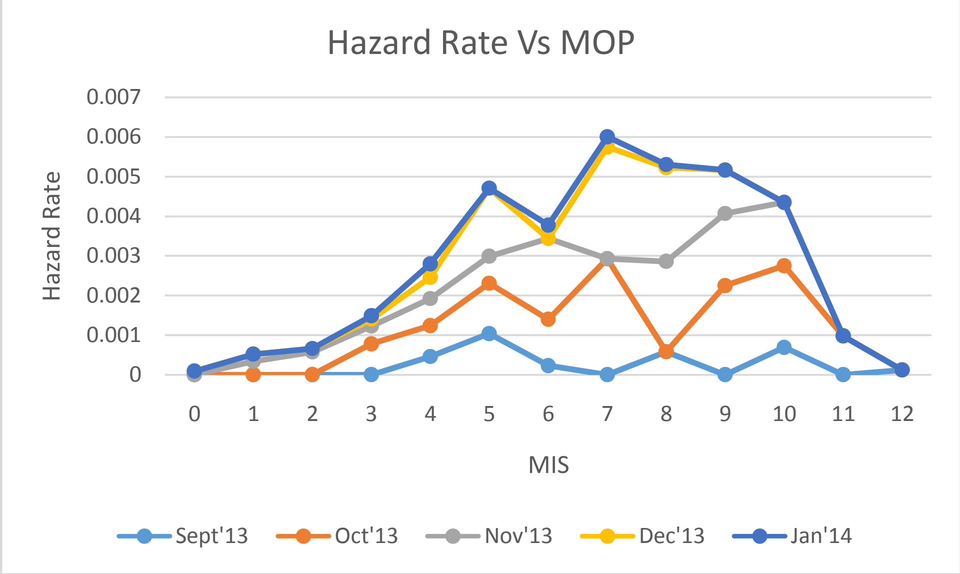

Figure 3 Hazard rate variation with MIS

Table A2 shows variations of cost per unit for month of production with successive month in service and figure 4 shows variations graphically, for successive month in service Cost per unit increases as month in service increases and afterwards it decreases, it has been observed that this much data analysis is not sufficient, therefore it requires parametric analysis for data.

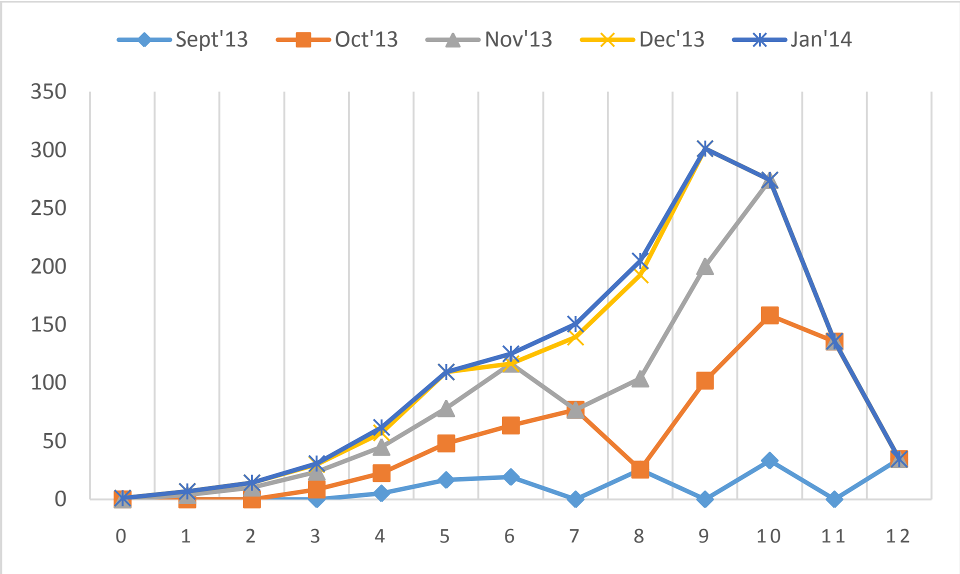

Figure 4 CPU Variation month wise

Conclusions:

Non parametric approach shows the variation in CPU and Hazard rate for Month in service of product, It shows that values are increasing as month in service increases. It concluded from above analysis reliability of product reduces over a time if problem in the product not identified. One can do parametric analysis to further identified problem.

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Appendix

Table A1 Cumulative Hazard rate for MOP with respect to MIS

MIS	Sept'13	Oct'13	Nov'13	Dec'13	Jan'14
0				0.00009	
1			0.00034	0.00018	
2			0.00057	0.00009	
3		0.00078	0.00045	0.00018	0.00008
4	0.00046	0.00078	0.00068	0.00054	0.00034
5	0.00104	0.00127	0.00068	0.00172	
6	0.00023	0.00117	0.00204		0.00034
7		0.00293		0.00282	0.00026
8	0.00058		0.00228	0.00237	0.00008
9		0.00225	0.00182	0.0011	
10	0.00069	0.00206	0.0016		
11		0.00098			
12	0.00012				

Table A2 CPU for MOP with respect to MIS

	Sept'13	Oct'13	Nov'13	Dec'13	Jan'14
0				0.999	
1			3.774	2.997	
2			10.1	3.996	
3		8.658	15.1	5.994	0.888
4	5.106	17.32	22.64	11.99	4.662
5	16.65	31.41	30.19	31.08	
6	19.2	44.4	52.84		8.436
7		76.92		62.38	11.32
8	25.64		78.14	88.69	12.21
9		101.9	98.35	100.9	
10	33.3	124.8	116.1		
11		135.6			
12	34.63				