

# Warranty Cost Modeling and Analysis

Mr. Saurabh Ambekar<sup>1</sup>, Mr. Madan M. Jagtap<sup>2</sup>

<sup>1</sup>Saraswati College of Engineering, Khartghar, India, saurabhambekar3@gmail.com

<sup>2</sup>Saraswati College of Engineering, Kharghar, India, jagtap.aero@gmail.com

## ABSTRACT:

For products sold with warranty, the manufacturer incurs costs resulting from the servicing of failures occurring under warranty. These costs depend on several factors, the most important being the reliability of the product. For planning purposes, the manufacturer must estimate the expected cost of warranty per unit sold and the expected cost per unit time over the product life cycle. This must be done in the product development stage. This article deals with models that may be used to obtain these cost estimates for products sold with free-replacement and *pro rata* warranties.

Key words: warranty; reliability; cost analysis; cost models

## INTRODUCTION

In present market, customers want that whatever he is purchasing; that product should give satisfaction during its useful life. So the manufacturer has to provide that assurance to customer. Otherwise manufacturer can't survive in this race.

Here the warranty introduces. It helps manufacturer to stay in market. Warranty gives –

- protection to manufacturer and buyer
- indication of product quality
- assurance of good performance of product
- right to buyer to compensate when a purchased object can't work satisfactorily as manufacturer said

### What is warranty?

“It is a written and/or oral manufacturer's assurance to a buyer that a product or service is or shall be as represented. It may be considered to be a contractual agreement between buyer and manufacturer that is entered into upon sale of the product or service. The contract specifies the

product performance, buyer responsibilities and what the warranty will do if an item purchased fails to meet the stated performance.”

### A. Types of Warranty –

There is generally two types

- a. 1 dimensional
- b. 2 dimensional.

#### 1) 1-d warranty (different policies)

##### a) Policy 1

Non renewing free replacement policy – in warranty period seller repairs or replaces the failed item in free of cost. Let the warranty period is  $W$ . After completing  $W$  period warranty gets finished.

It is non renewing means if object fails in  $W$  and then it get repair/replaced. After repair/replace it doesn't get another extra  $W_1$  period of warranty. Warranty expires on its initial  $W$  period only.

##### b) Policy 2

Basic rebate warranty policy – in this, seller refunded an amount which is equal to  $\alpha C$ . Where  $0 < \alpha < 1$ . But for refunding item should be in warranty period.

Here  $\alpha$  = scale parameter

$C$  = cost to buyer

##### c) Policy 3

Renewing pro-rata policy – in this, if item fails in  $W$  then for repairing manufacturer takes some cost from buyer to repair it. This cost is equal to  $(1 - X/W)C$ . After repairing/replacing an item he also provides another warranty on replaced item i.e. renewing policy.

Here,  $X$  = time to failure of an item

d) Policy 4

Pro-rata rebate policy – in this, if item fails in  $W$  then manufacturer refund fraction of  $C$ . the amount of refund is calculated on the basis of at which age item is failed. Refund is linear or non linear function of  $W - X$ , remaining warranty period.

$\alpha(1 - X/W)$  is the refund for linear pro-rata policy. When  $\alpha = 1$ ; then we get full pro-rated refund and less if  $\alpha < 1$ .

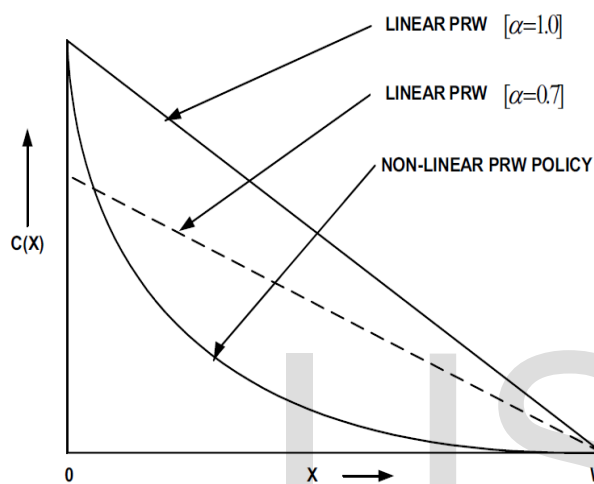


Figure 1: Rebate function for FRW policies

B. 2 dimensional warranty:

In this case warranty has two space dimensions. On one axis time or age is placed and on other item usage.

As we can see the importance of warranty, there is another important parameter related with warranty. It is cost analysis of warranty.

Providing warranty, there requires extra cost other than the actual price of product. Manufacturer sells it at  $C$  which includes that extra cost. This extra amount is called warranty cost.

This cost depends on

- reliability of product
- warranty type
- period length of warranty
- product type(electronics, mechanical, etc)

We can find out the importance of warranty cost from following example,

Warranty servicing cost (\$300 million for Ford, \$580 million for GM, \$200 for Chrysler in 1969) had increased significantly because product

reliability and quality were not good enough to support the longer warranty.

In late '60s manufacturers reversed their strategy and began decreasing warranty coverage, resulting in ill feelings among consumers.

I BASIS FOR WARRANTY COST ANALYSIS:

When in warranty period, item returned to manufacturers; both buyers and manufacturer encountered with following important costs –

1. warranty cost per unit sale
2. life cycle cost per unit sale

C. WARRANTY COST PER UNIT SALE:

Basic warranty cost is total amount required to do servicing on item. Warranty periods (WP) totally depends on warranty type. For 1-d non renewing warranty WP is  $W$ . One can get benefit of warranty only if the item fails in  $W$ . But in renewing policy the picture is different. It is shown in following fig.

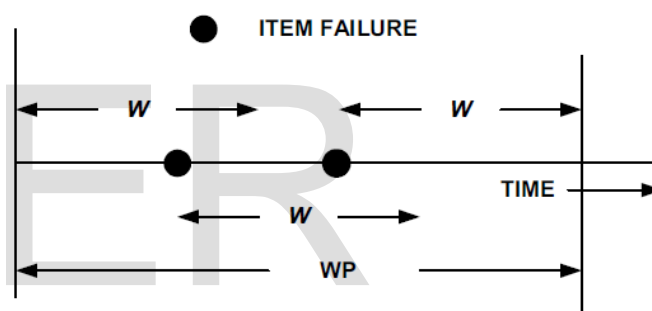


Figure 2: 1-D renewing warranty policy

For 2-d non renewing warranty there are two WP. One is decided on the usage of item ( $U$ ) and other is on the warranty time ( $W$ ). It is shown in following fig.

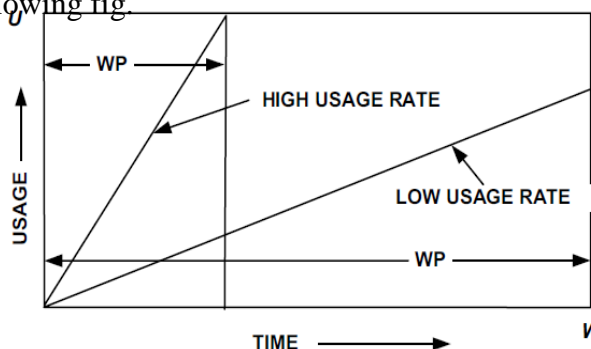


Figure 3: 2-D non renewing warranty policy

The warranty cost (i.e., the cost of servicing all warranty claims for an item over the total warranty period) is a sum of a random number of such individual costs, since the number of claims over the warranty period is also random.

Now, warranty cost for –

A. manufacturer :-

Warranty cost for manufacturer is the cost at which item is sold plus the servicing cost. In the analysis and examples presented, we give the expected (or average) value of this cost. This cost is important in the context of pricing the product. To stay in profit manufacturer should sale an item at cost exceeding this cost.

B. Customer :-

Cost to them is only initial purchasing price.

*D. LIFE CYCLE COST PER UNIT SALE*

Products like aircraft, automobile, locomotive are used for long periods. Product life (L) for such items ranges from 40 - 10 years. But the product life of component used in these items has short life than that of item. So we have to replace it after successive interval of time over period L. some time replacement has to be done after expiry of its original warranty (W). This replacement is covered by another warranty. Purchasing history is shown in following fig.

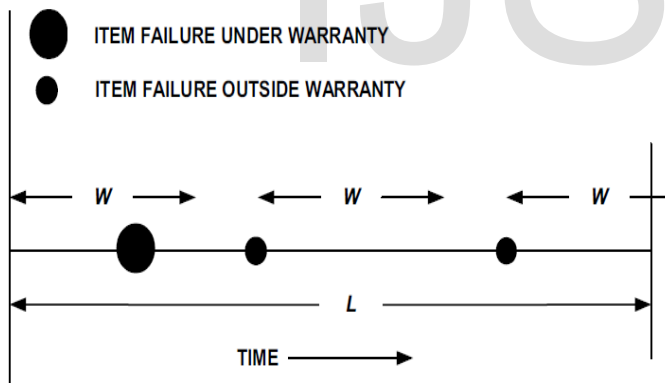


Figure 4: history of repeat purchase over L

Here, warranty cost for –

A. Manufacturer :-

Sum of production cost of item and servicing cost of item if it fails in original warranty period (W).

B. Customer :-

Purchase prize and cost related to warranty claims.

**II. METHODOLOGY FOR WARRANTY COST ANALYSIS**

Following fig. shows the flow chart for warranty cost analysis. From that one can predict, decide the warranty cost.

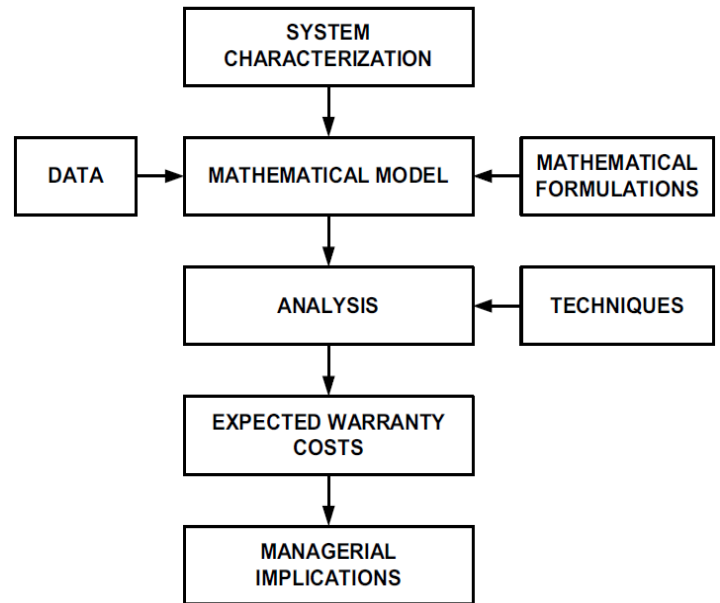


Figure 5: warranty cost estimation flow chart

*A. SYSTEM CHARACTERIZATION –*

Characterization is required to **formulate working cost model**. There are two system characterizations;

- Simple system characterization :

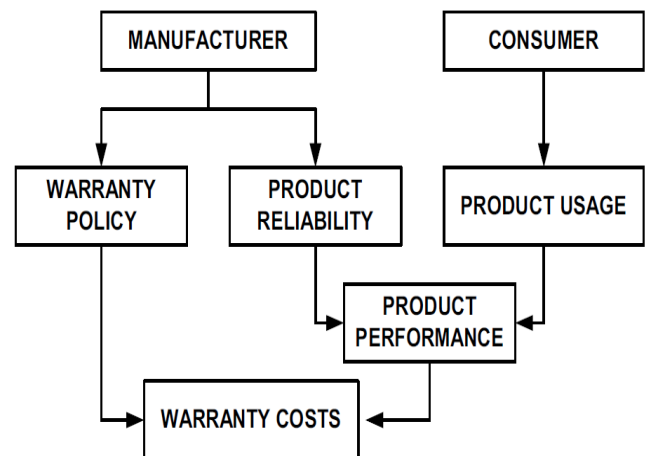


Figure 6: simple characterization

This model is useful to estimate the warranty cost per unit sale from both the point of view i.e. manufacturer and customer.

- Detailed system characterization :

- This chart is useful in estimating the life cycle costs.

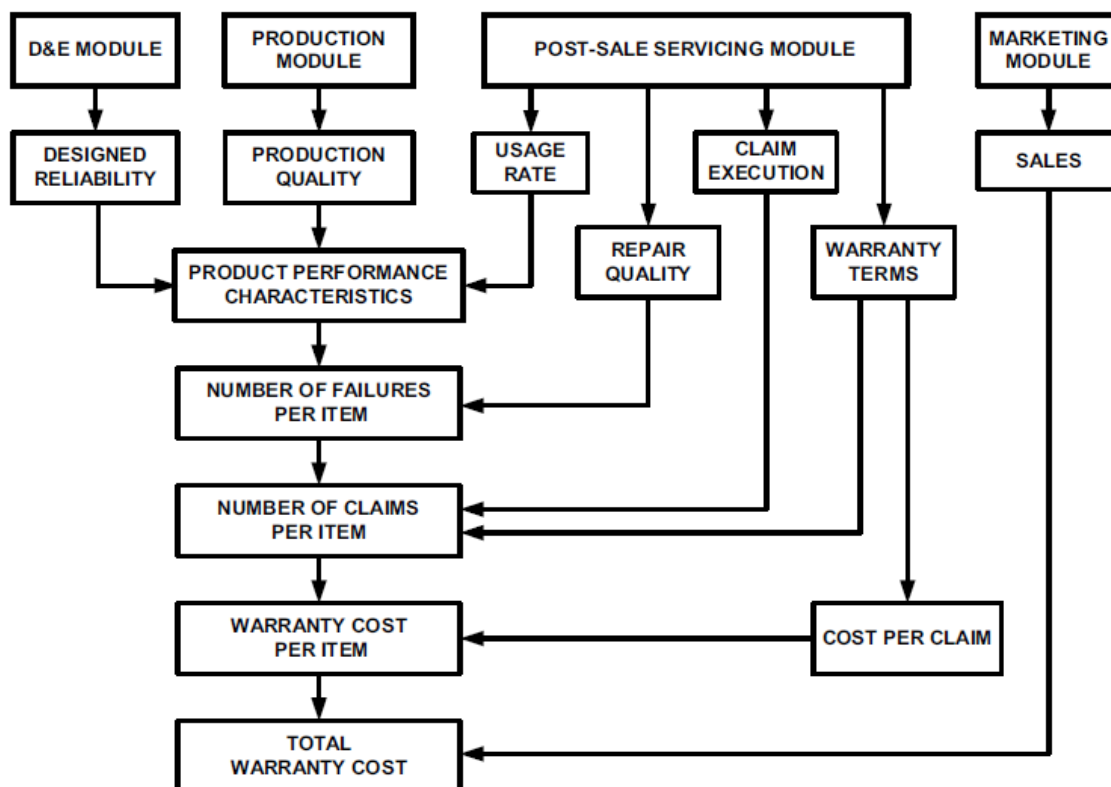


Figure 7: detailed system characterization

**B. MODELING –**

Cost models (considering manufacturer’s view) of warranty analysis depends on following factors –

1. Type of warranty given on sold item
2. Failure distribution of that item in warranty period

To model this failure distribution of items different probability distributions are used. Standard distribution is used to plot failure distribution of practically simple items.

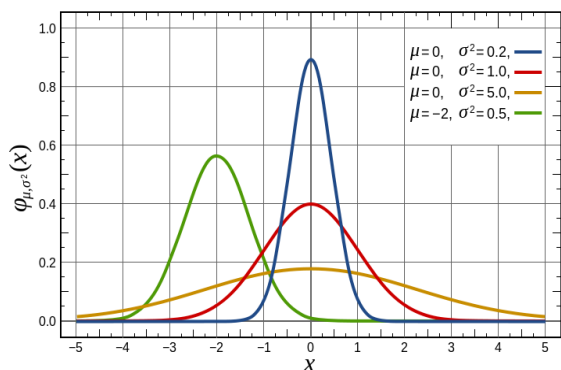


Figure 8: standard distribution (shown in red line)

To model failure pattern of complex item becomes very difficult. For that calculation we required computers.

**Results:**

- i. 1-D warranties :-

Univariate distribution is used to plot failure models of 1-d warranties. To select proper distribution we have to see whether there is failure data available or not. If yes then we use different distribution, if not we use another distribution.

Two parameter Weibull distribution is extensively used in reliability application.

$$F(x; \theta) = 1 - \exp \{-(x/\alpha)^\beta\}$$

Here,  $\theta = \text{set } \{\alpha, \beta\}$

Two parameters are  $\alpha, \beta$ .  $\alpha$  is non dimensional shape parameter. Distribution shape and failure rate function are determined by it. When  $\alpha = 1$ ; it means the failure rate is constant over period.  $\alpha < 1$ ; it means failure rate is decreasing over period.  $\alpha > 1$ ; it means failure rate is increasing over period.

$\beta$  gives idea of usage time.

- ii. 2-D warranties :-

Failure of items is plotted on two axes. One shows age and other use. We can model warranty cost in this warranty by two different approaches.

- a. APPROACH 1 (2-d approach) – On two axes time and use are plotted separately.
- b. APPROACH 2 (1-d approach) – only a variable called “usage rate” is plotted on axis. For a particular customer the usage rate is same. Therefore usage becomes linear function of time for that customer.

### Conclusion:

By doing all above process now we are ready to analyze the cost. For analyzing we have to take the help of mathematical and statistical techniques.

For easy problem we get its solution easily but for complex model we have to go through well designed warranty simulator.

For analyzing; we not only use above techniques but also the amount of information available.

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