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A conceptual framework for product design for warranty with focus on reliability, warranty policies and maintenance plans

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Abstract

Warranty can be considered as a legal contract which requires the manufacturer to either rectify or compensate for all failures occurring within the warranty period. Warranty of any type, since it involves an additional service associated with a product, will lead to potential costs. These costs depend on several factors such as the reliability of the product, warranty terms, maintenance actions and servicing strategy. Some are under the control of the manufacturer (such as the decisions made during the design and development of the product) and others under the influence and control of the consumer (such as the usage intensity, operating environment and maintenance).

To address the above and many other issues related to product warranties manufacturers need a framework that integrates the technology and commercial issues early at the design stage to minimize the warranty costs in the most effective and efficient manner. This is not easy because the link between parameters and warranty costs is complicated since each affects the other through multiple causal effect relationships. Quantitative models need to be built to implement any strategy for determining optimal reliability, warranty policies and maintenance plans for improved warranty performance. The proposed paper aims to develop a conceptual framework to address critical issues that affect warranty costs.

Keywords: warranty, reliability, maintenance, warranty management, models, warranty cost.

1. Introduction

New products have been appearing at an increasing pace with industrial revolution. The complexity of the products has increased significantly to meet the ever increasing needs and expectations of consumers. In the purchase decision of a product, buyers typically compare characteristics of comparable models of competing brands. When competing brands are nearly identical, it is very difficult, in many instances, to choose a particular product solely on the basis of the product-related characteristics such as price, special features, perceived product quality, financing offered by the manufacturer, and so on. In such situations, post-sale factors -

warranty, parts availability and cost, service, maintenance etc. are important in choice of the product. Of these, warranty is a factor that is known to the buyer at the time of purchase.

All products are unreliable in the sense that they fail. A failure can occur early in an item's life due to manufacturing defects or late in its life due to degradation that is dependent on age and usage. Consumers need assurance that the product will perform satisfactorily over the useful life of the product. In addition, the legislations are getting more stringent to protect consumer interests. Manufacturers have responded to these challenges by offering longer warranties and extended warranties.

A warranty is a contract between buyer and manufacturer associated with the sale of a product. In broad terms, the purpose of a warranty is to establish liability among the two parties (manufacturer and buyer) in the event that an item fails. An item is said to fail when it is unable to perform satisfactorily its intended function when properly used. The contract specifies both the performance that is to be expected and the redress available to the buyer if a failure occurs.

A warranty of any type, since it involves an additional service associated with a product, will lead to potential costs beyond those associated with the design, manufacture and sale of the product. The warranty costs depend on the reliability performance of the product. This in turn depends on several factors some under the control of the manufacturer (such as the decisions made during the design and development of the product) and others under the control of the consumer (such as the usage intensity, operating environment and maintenance).

The warranty servicing costs vary from 2-10 % of sale price depending on the product and the manufacturer. The total warranty costs for General Motors and Ford were over 4 billion dollars each for 2006 (Murthy, 2007). As a result, warranty and product reliability are very important in the context of product development.

2. Parameters affecting Warranty Cost

2.1.Warranty Policy

Blischke and Murthy (1992) proposed a taxonomy for warranty policies for new products and grouped these policies into three categories, such as Type A (single item sale and not involving product development and also can be divided into one and two-dimensional policies), Type B (group of items and not involving product development) and Type C (involving product development).

Murthy and Chattopadhyay (1999) developed policies and taxonomy for secondhand products. Warranty policies were classified under three groups, namely Group A (non-renewing policies), Group B (renewing policies), and Group C (buy-back policies, under these policies the dealers are bound to return the money to the buyer, if the product fails any time during the warranty period).

2.2. Product Reliability

Reliability of a product conveys the concept of dependability, successful operation or performance and the absence of failures. It is an external property of great interest to both manufacturer and consumer. The reliability of a product (system) is the probability that the product (system) will perform its intended function for a specified time period when operating under normal (or stated) environmental conditions. (Blischke and Murthy, 2000)

Failures over the warranty period are closely linked to product reliability. The reliability of a product gets determined by the decisions made during the pre-production stages (Frontend, Design and Development) as well as the production stage of the product life cycle. Murthy et al. (2007a and 2009) deal with reliability decision making during the Front-end (or Feasibility) and the Design and Development stages of new product development.

Hahn et al. (2008) described methods of implementing quality control techniques for various processes in business enterprises and to improve reliability of equipment, based on analysis of data pertaining to warranty.

2.3. Maintenance Plans

Preventive Maintenance (PM) over the warranty period has an impact on the warranty servicing cost. It is worthwhile for the manufacturer to carry out this maintenance only if the reduction in the warranty cost exceeds the cost of PM. However, it is worthwhile to carryout maintenance as it affects the overall health of the machine in future. A myopic buyer might decide not to invest in any PM over the warranty period, as item failures over this period are rectified by the manufacturer at no cost to the buyer.

Huang and Yen (2009) developed a two-dimensional warranty model in which the customer is expected to perform appropriate preventive maintenance is analyzed and the warranty policy that maximizes the manufacturers' profits is determined.

Ben-Daya and Noman (2006) developed an integrated model that considers simultaneously inventory production decisions, PM schedule, and warranty policy for a deteriorating system that experiences shifts to an out of control state.

Jung and Park (2003) developed the optimal periodic preventive maintenance policies following the expiration of warranty by minimizing the expected long-run maintenance cost per unit time. Djamaludin et al. (2001) developed a framework to study warranty and maintenance. Kim et al. (2004) proposed a model to determine discrete time instants when preventive maintenance actions are to be carried out over the warranty period.

2.4.Warranty Logistics

Warranty logistics deals with various issues relating to the servicing of warranty. Proper management of warranty logistics is needed not only to reduce the warranty servicing cost but also to ensure customer satisfaction, as customer dissatisfaction has a negative impact on sales and revenue. Complex products (such as an aircraft engines or industrial equipment) degrade and fail due to age and/or usage. As such, they need to be maintained over the life of the product (which can vary from 15 to 20 years or more in some cases).

Blanchard et al. (1995) deal with maintenance management and Blanchard (1998) with some related logistical issues. The linkage between product distribution and service support channels is discussed in Loomba (1996).

Alfredsson (1997) deals with location of repair facilities. Dasci and Verter (2001) deal with location in the context of production–distribution system. Owen and Daskin (1998) deal with strategic facility location.

As can be seen from the above discussion, minimization of warranty cost is a multidimensional problem. In addition to this, the complexity of the problem is very high due to the way in which these parameters affect warranty cost.

In this paper, we present a framework for modeling the impact of some of the most important parameters on warranty cost and eventually on profits.

3. The Proposed Conceptual Framework

From the business perspective, there can be multiple goals such as market share, total profits etc. Warranties not only impact total sales in a positive manner (due to their promotional effect), but also warranty cost and profit margin. The Figure 1 shows the link between warranty parameters and warranty cost.

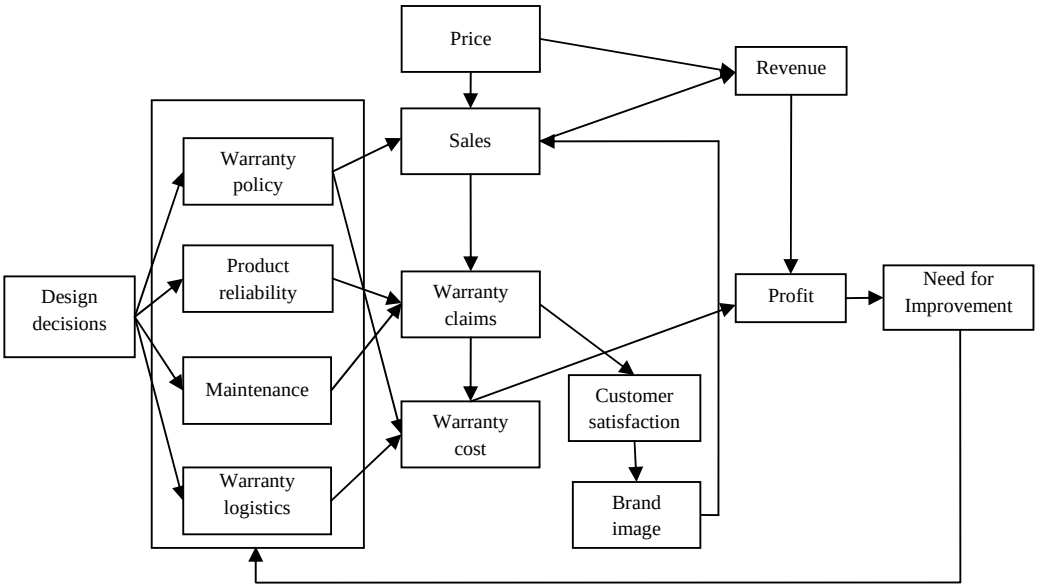

Figure 1: Conceptual Framework

As the failure of the product is based on the reliability of the product, it will affect warranty claims. With increase in product's reliability, the number of warranty claims will decrease. Not having adequate reliability is costlier as failures result not only in higher warranty costs but also reduced sales and revenue due to the negative impact of customer dissatisfaction resulting from product failures. The data related to inherent reliability of components can be obtained from component manufacturers and from life tests conducted by the design and development department. The warranty claim data can be used for analysis of failures and to make subsequently improvements into the design of the product. The warranty claim data can be obtained from the dealers, service agents as well as the feedback obtained from the customers. Many web based warranty management softwares are available in the market. These can help in effective processing of warranty data.

In a competitive environment, the total demand for first purchase sales depends on product attributes. These include the sales price and the warranty terms of the products. Manufacturer reputation depends on the reputation of its products and has a strong influence on the first purchase decisions of new customers. Product reputation has a similar effect on repeat purchase decisions. The sales data of the product compared to the competitor's sales volume as well as share of the product in

the market can be used set the benchmarking and building the reputation in the market.

The type of maintenance will affect the number failures and consequently the number warranty claims. For warranty periods, the manufacturer can minimize the expected warranty claims through optimal maintenance decision making and this reduces the likelihood of failures. Optimal preventive actions need to be viewed from a life cycle perspective for the buyer and manufacturer (Murthy and Jack, 2003).

Apart from design related issues, warranty logistics plays an important role in controlling the warranty cost. The manufacturer needs a dispersed network of service facilities that store spare parts and provide a base for field service. The service delivery network requires a diverse collection of human and capital resources and careful attention must be paid to both the design and the control of the service delivery system. The data related to the requirement of spare parts can be obtained from the sales department. Warranty logistics related data can be acquired from the service agents and dealers, who provide the service to the customers.

The feedback for product can be obtained through customer in the form of feedback reports, consumer surveys, and warranty claim data/ failure data obtained from the dealers and service agents. Collected data provides ability for an organization to track product failures and defects in order to recover warranted repair/part/labor costs from suppliers. Warranty claim data will be useful in early warning/detection of bad design, poor production processes, defective parts, poor materials, etc. Manufacturers analyze field reliability data to enhance the quality and reliability of their products and to improve customer satisfaction. The quick feedback mechanism needs to be developed in order to make the improvements as early as possible and reducing the number of defective units to be produced.

4. Data Collection Mechanism

Mechanism for capturing relevant data from external and internal resources.

Internal data can be obtained from different sources like

- Design and development: It includes data related to reliability, design, evaluating preliminary designs and design improvements.
- Production: It includes product quality related data, inspection cost data, process improvement, outsourcing components data.
- Marketing data: It includes pricing, usage data, sales data, assessment of customer satisfaction, evaluating the competition.
- Post support data: It includes data related to product performance, tracking warranty claims, failure causes and frequencies, repair data, estimating warranty cost.

External data can be obtained from

1. Partners in the supply chain such as,

- Dealers and service agents: Warranty claim and failure data can be obtained from dealers and service agents. It will provide valuable information regarding product performance in the field. It will also provide information such as usage mode and intensity. Care is to be taken for invalid data like claims made after expiration of warranty, failures due to misuse etc.

- Component suppliers: Test data related to component reliability can be obtained from the suppliers and can be verified by in-house testing. Field failure data collected by supplier from their own sources can also be used.

2. Customer/ customer reports: Warranty claim data and failure data which customer have informed directly to manufactures through feedback reports.
   Some third party organizations carryout different kinds of tests on products and conduct customer surveys. The findings of their studies are usually reported in magazines or reports and constitute a valuable source for relative comparison between different products.

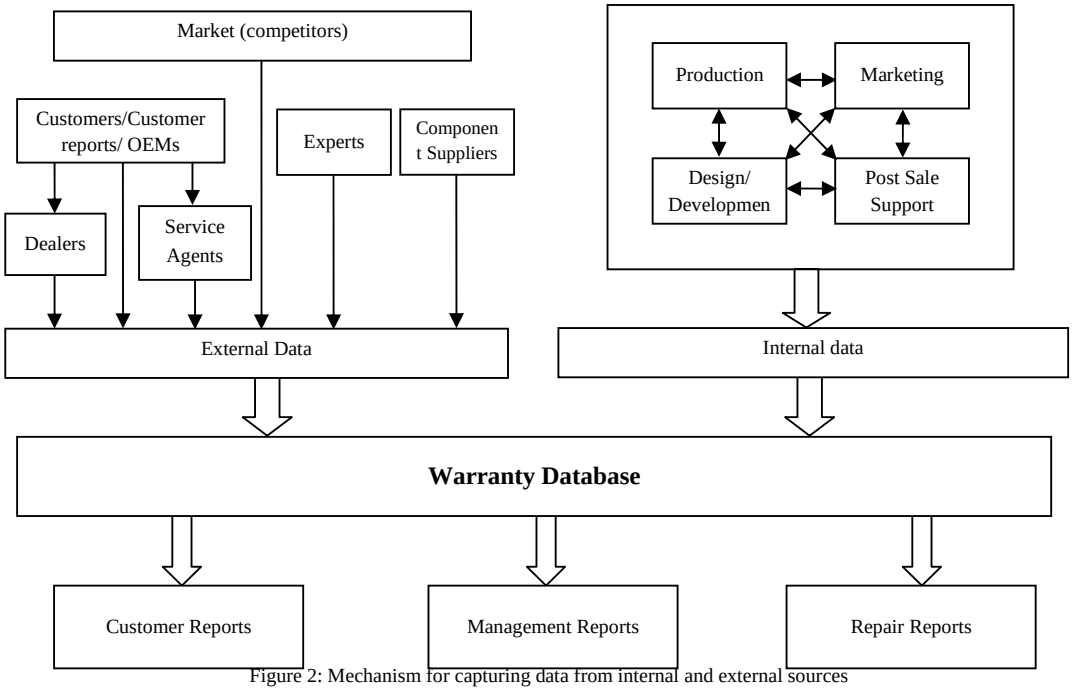

Figure 2: Mechanism for capturing data from internal and external sources

   If the product is a part of assembly and it is supplied to the OEMs then in this case the customers are the OEMs e.g. In case of engines, these are supplied to vehicles manufacturers (OEMs) so in this case OEM is customer.

3. Experts: Experts are the source of intuitive and judgmental data. This type of data is useful in situations where little or no data is available.
4. Market (competitors): It can be carried out to obtain the information regarding similar competing products; this type of data can be useful for setting benchmark.

From the above data, different reports can be generated like customer reports, management reports and repair reports which give information about the warranty attributes. A mechanism for capturing warranty related attributes is as shown in Figure 2.

5. Conclusion

In this paper a conceptual framework is proposed that integrates the technology and commercial issues early at the design stage of the product to minimize the warranty costs in the most effective and efficient manner. It can be carried out

through development of an integrated model for warranty optimization. Warranty costs can be reduced with improved product reliability, appropriate warranty policies and optimal maintenance plans.

The Conceptual framework proposed in this paper will further motivate researchers to work in this area.

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