

Cost Analysis of Two-Attribute Warranty Policies Based on the Product Usage Rate

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Abstract—In the so-called two-attribute warranty policy, two types of warranty criteria, such as the age and mileage of an automobile, are employed simultaneously to determine the eligibility of a warranty claim. We propose in the paper several decision models that estimate the expected total cost incurred under various types of two-attribute warranty policies. We also perform a sensitivity analysis to study the effects of several model parameters, such as the discount rate, the product usage rate, and the warranty terms, on the total warranty cost.

Index Terms—Product failure process, two-dimensional warranty, warranty cost.

I. INTRODUCTION

IN their simplest form, warranties obligate a manufacturer to compensate the consumer in the event of product failure; they are a form of insurance. This insurance is bundled together with the product and offered to all consumers at the time of purchase. Nearly everything purchased, by an individual or an organization, is covered by a warranty—expressed or implied. Undoubtedly, the accurate estimation of the total warranty cost that should be put into reserve to meet future warranty claims is one of the most important tasks in engineering management.

Too little warranty reserve results in unexpected reduction of profits; too much is likely to make the sales price noncompetitive, thereby reducing sales volume and profit. For accounting purposes, the Financial Accounting Standards Board (FASB) also requires that after-sale costs associated with warranties be recognized in the accounts during the year of the product sales so as to reflect a proper matching of revenues and expenses.

The objective of this paper is to propose and analyze several decision models that estimate the total warranty cost of a product sold under various types of warranty policies. In particular, the following questions will be addressed from the manufacturer's perspective. 1) What is the cost of offering a specific two-attribute warranty policy? 2) How does this compare with other single—or two-attribute warranty policies? 3) How does the warranty cost obtained in the model change with the parameters of the warranty policy?

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Since warranty claims occur in the future after the product is sold, the present value of the total repair cost must be reduced by the opportunity to invest and earn profits from the warranty reserve. Analytically, the warranty cost is calculated in this paper such that it equals the expected present value of total future repair costs of a product sold under warranty. Although the present value of repair costs has been widely considered in the context of the single-attribute warranty policy, the authors are unaware of any other efforts that explicitly incorporate the present value concept for a two-attribute warranty policy.

In most two-attribute warranty policies offered in the U.S. automobile industry, the repair service is usually provided at no cost to the consumer during the warranty period. In addition to such a free-replacement warranty policy, we also consider in this paper a pro-rata, two-attribute warranty plan, under which consumers are required to pay a fraction of the full repair cost based on the age and the usage of the product at the time of breakdown.

In Section II, various types of warranty policies will be briefly reviewed in order to clearly define the warranty policies considered in the paper. For more detailed classifications, see [2].

II. WARRANTY POLICIES

Let c denote the average full repair cost on any particular breakdown of a product. Since a failed product is repaired at a fraction of the full repair cost c (or at no cost) under a warranty policy, let c_p denote the portion of the full repair cost incurred to the producer, i.e.,

$$c_p = c[1 - k(t)], \quad \text{where } 0 \leq k(t) < 1. \quad (1)$$

Based on the fraction $k(t)$ in (1), we can classify warranty policies into three groups: free-replacement; lump-sum; and pro-rata. When $k(t) = 0$, for example, the warranty policy is called a free-replacement warranty, under which a producer provides as many replacements or repairs as needed free of charge to a consumer during the warranty period. If $k(t)$ is a constant over the range $0 < k(t) < 1$, then the warranty policy is called a lump-sum warranty, under which a customer receives a fixed or lump-sum rebate for any product failures occurring within the warranty period. If $k(t)$ is a function of product age t , on the other hand, then the policy is called a pro-rata warranty, under which a consumer must pay a fraction of the full repair cost.

Based on the number of warranty variables used in defining the warranty conditions, we can also classify warranty policies