DEVELOPING AND MEASURING THE CONCEPT OF WARRANTY PREMIUM

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Abstract

The concept of warranty premium is defined and developed in terms of the risk reduction role of warranties and the signal of quality that warranties provide. The paper shows how warranty premium can be modeled and measured. The model is found to have good predictive ability in the experimental test conducted.

Introduction

There has been increasing interest in understanding the role of product warranties. Some researchers have examined warranties from a consumer perspective, analyzing the relationship between consumers' attitudes to warranties and their projected behaviors (Darden and Rao 1979), the effect of warranties on perceptions of financial and performance risks (Shimp and Bearden 1982), and whether warranties are good signals of product quality (Wiener 1985). Other researchers have described managerial warranty practices (Udell and Anderson 1968, Kendall and Russ 1975, Menezes and Quelch 1990), and some have provided guidelines for improving the effectiveness of warranty programs (Fisk 1970, Menezes and Quelch 1990).

One neglected issue, in the literature cited above, is an assessment of the value of a warranty to a consumer. Little research has been done to assess the "warranty premium", i.e., the additional amount that a customer would be willing to pay for a product with a warranty over one without a warranty. Research on understanding and assessing the value of a warranty is important for two reasons. First, research on the value of a warranty will help advance the rather limited theory that has been developed on the impact of product warranties on consumer preferences. Second, manufacturers and retailers often offer and promote their warranties based on the belief that warranties increase the value of the product and influence consumer preferences. A better understanding of and an approach to measuring the value of a warranty could help these manufacturers and retailers in their pricing decisions.

The purpose of this paper is to develop the concept of warranty premium and show how it can be modeled and measured. The validity of the derived result is then tested through an experiment.

Previous Research

In addition to the marketing literature covered in the introduction, product warranty has attracted attention in a few other areas such as management science, industrial engineering, insurance, and economics. These are now briefly reviewed.

The industrial engineering and management science literatures analyze warranties in terms of their relationship to costs (Mamer 1982, Mitra and Patankar 1988), product reliability (Heschel 1971), reserves (Amato and Anderson 1976, Menke 1969, Thomas 1989), and cash flows (Patankar and Worm 1981).

The insurance literature tends to focus on regulatory and equilibrium issues, with an emphasis on establishing equilibrium conditions. For example, Stiglitz (1977) focuses on equilibrium conditions for a monopolist while Rothschild and Stiglitz (1976) examine equilibrium conditions in competitive insurance markets. The economics literature focuses on social welfare and regulatory/legal issues. Some researchers study the sharing of liability (Brown 1974, Spence 1977), others take a social welfare and public policy perspective (Courville and Hausman 1979, Palfrey and Romer 1983), and yet others examine warranties when moral hazard problems play a central role (Cooper and Ross 1985, Kambhu 1982).

This paper adds to the literature in that it focuses on the value of a warranty to the consumer, a neglected issue in the literature.

Concept of Warranty Premium

A customer may be willing to pay a different price (usually higher) for a product with a warranty as compared to a product without a warranty, because the warranty may be perceived to be providing some value to him/her. The concept of warranty premium is introduced to capture this.

We define Warranty Premium (WP) as the amount that an individual is willing to pay for a product with a warranty (P_W) over and above the price that he/she would pay for the product without a warranty (P): $WP = P_W - P$. (By "products without a warranty" we refer to products that either have no warranty or have very short warranties, e.g., 30 days, merely to meet legal requirements and protect customers from the risks associated with purchasing a lemon.)

Warranties may provide value to customers in two major ways. First, warranties may help reduce the risk associated with the purchase of the product, and second, warranties may impact the perceived value of a product or service by providing a signal of product quality. Each of these is briefly reviewed.

Warranty as a risk reduction mechanism: The purchase of several product categories involves substantial risk, and a major role of a warranty is to reduce that risk (Shimp and Bearden 1982). Consequently, this impacts the consumer's preference for the product and his/her willingness to pay for the product. This impact depends on the risk attitude of the individual.

The warranty premium is expected to be higher the more risk averse the person is. A constant absolute risk aversion, captured by an exponential utility function, is used here because it has been used extensively by researchers and found to provide accurate predictions (Currim and Sarin 1989, Roberts and Urban 1988) and to fit data quite well (Fishburn and Kochenberger 1979). Since for payments of $x, the utility function U(x) is a decreasing function of x, the utility function can be modeled as U(x) ={1-exp(Cx)}/{exp(C)-1} for C=0, and U(x)=x for C=0, where C is the risk preference parameter. Since the absolute risk aversion r(x) = C, for a risk averse person C will be positive, for a risk neutral person C will be equal to 0 and for a risk prone person C will be negative. The warranty premium is expected to increase with the value of C.

Warranty as a quality signalling mechanism: A warranty provides an effective way for a firm to communicate to customers about the product's quality. Thus, warranties could influence the likelihood of product failure and consequently the amount that the customer is willing to pay for the product. A warranty is a good signal of product quality because it meets the requirements of an informative signal: (i) it increases manufacturer costs and (ii) these costs are systematically related to the warranty coverage and product quality (Spence 1977). Thus, consumers may perceive a positive relationship between warranty and product quality.

On the other hand, some consumers may believe that a firm with a lower-quality product and low sales may, in order to survive, enhance its warranty to attract customers to buy the product. These customers may see the firm as attempting to increase sales, achieve short-term profitability and postpone warranty costs, while simultaneously working on improving its product quality for long-term survival. These consumers will perceive there to be a negative relationship between warranty and product quality. This view is supported by some empirical evidence that, at least for some product categories, warranty coverage bears an inverse relationship to the reliability of the product (Garvin 1983).

Some consumers may perceive warranty coverage and product quality to be unrelated (Shimp and Bearden, 1982). This perception would cause warranty terms to be quite similar, despite differences in product quality. This is precisely what Gerner and Bryant (1981) found in a study of five different product categories--refrigerators, ranges, air conditioners, television sets, and washing machines.

It is thus apparent that a positive warranty-quality relationship has strong theoretical support, while negative and no warranty-product quality relationships have some empirical support. While this is an area for future investigation, in this work we consider all three possible warranty-product quality relationships and our empirical work manipulates consumers' perceptions of this relationship.

To more fully examine the nature of warranty premium we represent the product without a warranty as having some probability (α) of failure and a complementary probability ($1-\alpha$) of adequate performance. When the product works fine the cost to the consumer is the purchase price P. However, when the product fails, there is a additional cost L to repair the product. When a product fails, consumers typically incur some costs in addition to the repair costs L. These additional costs, which we refer to as transaction costs T, are the implicit costs to the consumer in terms of the inability to use the product during its failure and the time, effort, and inconvenience associated with the repair. Thus, the total cost to the customer when the product without a warranty fails is P+L+T (see Appendix). On the other hand, the product with a warranty can be represented as having some probability (β) of failure and a complementary probability ($1-\beta$) of adequate performance. Let WP represent the additional amount that the consumer is willing to pay for the product with the warranty. For a product with a warranty, if the product works fine, the cost to the consumer is P + WP; and if the product fails, the cost to the consumer is P+WP+T. (This assumes that the transaction cost T is the same whether or not the product has a warranty.)

Using utility theory we derive results for warranty premium (see Appendix):

For risk-averse and risk-prone individuals:

$$\text{Warranty Premium} = \frac{1}{C} \ln\left[\frac{e^{C(L+T)} + (1 - \alpha)}{\beta e^{CT} + (1 - \beta)}\right] \quad (1)$$

For risk-neutral individuals:

$$\text{Warranty Premium} = \alpha(L+T) - \beta T \quad (2)$$

Thus, the additional amount that a customer would be willing to pay for a product with a warranty (warranty premium) is impacted by several factors such as the risk attitude (C) of the individual, the quality signal provided by the warranty, i.e., the perceived likelihood of product failure with and without a warranty (α and β), the expected costs of product repair (L), and the cost associated with the inability to use the failed unit and the individual's time, effort, and inconvenience in repairing the failed unit (T).

Method

Subjects: The subjects were 235 MBA students at a major university. Use of students as subjects in this experiment was appropriate because the objective of the study was to test the concept and derived results, and these should be valid for all consumers, including students. Based on exploratory research and pretests, the Compact Disc Player was selected as the product to be used in the experiment.

Procedure: Subjects were first explained the nature and purpose of the study. The stated

objective was to understand and model how people make decisions under conditions of uncertainty.

Subjects were then given a questionnaire that was developed based on several pretest studies. In the questionnaire subjects were presented four scenarios, each of which indicated a probability p_i that they would incur a product related repair loss L and a complementary probability that they would incur no loss. Subjects had to indicate an amount x at which they would be indifferent between x and the gamble. The scenarios differed in terms of the loss probability, and the order of the scenarios was randomized to reduce any possible bias resulting from anchoring, assimilation, and contrast effects. These questions were used to measure the individual's risk attitude.

Next, subjects read a report on Compact Disc Players attributed to a well-known product testing publication. It described the product and rated eight brands (no brands names given) in terms of quality (reliability), warranty length, and other product features. The report established and then restated the relationship between warranty and product reliability. This relationship was manipulated across the three treatment conditions. In one condition, the study reported a positive relationship between warranty and product quality. It reported that high-quality brands had long warranties and low-quality brands had short warranties, and included a summary statement that highlighted the relationship. In the second condition, the report established a negative relationship between warranty and product quality, and in the third condition, the report established that warranty terms and product quality were unrelated.

Subjects were then presented with five pairs of hypothetical Compact Disc Player descriptions. In each pair, the two products (no brand names were given) were described in terms of warranty length (a short 30-day warranty on one and a longer warranty on the other), product failure rate (given as unknown for the product with a warranty), repair cost, and the price differential between the products. For each pair, subjects had to indicate which product they preferred, and the price differential between the two products at which they would find the two products equally attractive. Subjects were also asked to indicate their estimate of the failure probability of the product whose failure rate was given as unknown. Finally, subjects were asked a few questions to measure their involvement with the product, their level of interest in and experience with the product, their attitude toward the task, and the value of the time and inconvenience associated with having the product repaired. They were also asked some socioeconomic questions such as their age, sex, and savings.

Analyses And Results

Manipulation Check: To check the effectiveness of the warranty-quality relationship manipulation, we examined the treatment condition in which a subject was, and checked whether the subject's estimate of the failure probability was in accordance with that treatment condition. For example, if a person received a negative warranty-quality relationship report, the manipulation was deemed successful if that person estimated the failure probability of the product with a warranty to be greater than the failure rate of the product without a warranty. The manipulation was successful for 94% of the subjects.

Determination of Risk Preference Parameter: The subjects' utility functions were estimated based on their responses to questions asking for their indifference values to four different scenarios, each involving a loss of L (-$400) with probability p_i and no loss with probability $(1-p_i)$. Setting the utility of 0 equal to zero and the utility of -400 equal to -1, the utility function is modeled as:

$$U(x) = \frac{1 - e^{C(x/-400)}}{e^{C} - 1}$$

where C is the risk preference parameter. Based on the questions asked, $U(x_i) = -p_i$, and the value of C_i is obtained for each scenario by solving:

$$-p_i = \frac{1 - e^{C(x/-400)}}{e^{C} - 1}$$

Thus a value of C_i is calculated corresponding to each question. Error is allowed for by selecting a value of the risk-preference parameter that minimizes the stress of fit across all four scenarios. Based on the risk preference parameter (C), we found that 117 subjects (50%) were risk averse, 89 (38%) were risk prone, and 29 (12%) were risk neutral. The values of C ranged from -5.00 to 3.20 with a mean of -0.06. We found that the risk preference of an individual was not related to the warranty-quality relationship that the individual was exposed to ($\chi^2_4 = 0.721 < \chi^2_{4,.05} = 9.49$). The risk preference parameter did not significantly differ by sex (mean -0.13 for females and -0.02 for males).

Warranty Premium Model

The data were split into two groups; 80% to be used for calibration and 20% for validation. This percentage split of the data between calibration and validation is in line with the findings of Vonhanacker and Steckel (1990).

Model Calibration

Using the calibration data the warranty premium was estimated by OLS regression. Various nested versions of the models were estimated to see the improvement in the model by adding variables (the decision rule for adding variables was to choose that variable contributing maximally to model fit). Model improvement and quality of fit were evaluated by the F ratio.

The results (see **Table**) show that all significant parameters have the expected sign. Also, the explanatory power of the model is high, as is evident from the fit of the model WPM_5 (R^2 = .554). The signaling effect of warranties and the risk preference parameter are the most

TABLE

WARRANTY PREMIUM MODEL

Parameter Estimates (t-values)

	WPM_1	WPM_2	WPM_3	WPM_4	WPM_5	WPM_6
Constant	68.19 (36.92)[a]	70.00 (43.96)[a]	70.83 (45.58)[a]	35.34 (5.17)[a]	2.72 (.17)	1.21 (.10)
Signal	294.75 (22.00)[a]	303.59 (26.32)[a]	235.57 (16.16)[a]	231.21 (16.07)[a]	232.22 (16.16)[a]	229.81 (15.84)[a]
Risk Preference		23.83 (18.18)[a]	24.00 (18.82)[a]	23.94 (19.04)[a]	23.96 (19.10)[a]	23.95 (19.10)[a]
Transaction Cost x Signal			2.33 (7.32)[a]	2.34 (7.47)[a]	2.34 (7.47)[a]	2.48 (7.42)[a]
Failure Probability x Loss				0.57 (5.33)[a]	0.54 (5.00)[a]	0.54 (5.00)[a]
Loss					0.09 (2.17)[a]	0.09 (2.13)[a]
Transaction Cost						0.08 (1.18)
R^2 (adjusted)	0.340	0.512	0.538	0.551	0.554	0.554
F	484.230[a]	492.310[a]	354.420[a]	288.420[a]	194.140[a]	194.140[a]
Comp. F	-	330.710[a]	53.580[a]	28.450[a]	6.100[a]	1.40

[a] $p < .01$

important variables in explaining warranty premium. Transaction cost x signal (which captures the transaction premium) and failure probability x loss (which is the expected loss) are also variables that significantly improve the model and the parameter estimates have the expected sign. The next significant variable is the loss amount. However, adding the transaction cost to the model is not useful because both the parameter estimate and the improvement in the model are not significant. Thus, WPM_5 is the most suitable model and is used in further analysis:

$$\underset{(16.0)}{WP = 2.72} + \underset{(1.25)^a}{23.95\ C} + \underset{(14.37)^a}{232.22\ (\alpha-\beta)} + \underset{(.31)^a}{2.34\ (\alpha-\beta)T} + \underset{(.11)^a}{0.54\ \alpha L} + \underset{(.04)^a}{.09\ L}$$

$R^2 = .554$

a: denotes significance at the 0.01 level

To test the stability of the parameter estimates, the model was estimated after eliminating 10% of the observations and the results compared with the earlier model using the Chow test. The analysis shows that the parameter estimates are stable ($F = 0.92$, $< \text{critical } F_{90,847} = 1.00$).

For each individual we computed the warranty premium (WPC) using equations 1 and 2. The mean computed warranty premium was \$63.20, the mean actual warranty premium (WP) was \$64.82, and the correlation between the computed warranty premium (WPC) and the actual warranty premium as stated by the respondents (WP) was found to be 0.52 (significant at the 0.01 level).

Model Validation

Some validity for the proposed warranty premium model is provided by the fairly good overall fit and significant parameters with the expected sign. A better test of the accuracy of the model is to explore its ability to correctly predict the values in the validation set.

The prediction quality of the model is often measured by Theil's (1966, p 26-35) inequality coefficient U as shown below:

$$U = \frac{\sqrt{\frac{1}{n-n^*}\sum_{i=n^*+1}^{n}(WP_i - \hat{WP}_i)^2}}{\sqrt{\frac{1}{n-n^*}\sum_{i=n^*+1}^{n}WP_i^2} + \sqrt{\frac{1}{n-n^*}\sum_{i=n^*+1}^{n}\hat{WP}_i^2}}$$

Where $\hat{WP}$ is the estimated warranty premium, n is the total sample size, n^* is the number of observations in the calibration sample, and $n-n^*$ is the number of observations in the validation sample. U ranges from 0 to 1, with smaller values representing better predictions. The value of U was found to be .2720, indicating good prediction.

Another test of the predictive ability of the model was conducted with the validation data by running a regression of actual warranty premium as a function of the predicted warranty premium:

$$WP = A_0 + A_1\hat{WP}$$

and testing whether $A_0 = 0$ and $A_1 = 1$. The result of the estimation is given below:

$$WP = 2.739 + 0.976\ \hat{WP}$$
$$(4.99)\quad (0.06)$$
$$R^2 = .53.$$

Analysis shows that A_0 (2.739) is not significantly different from 0 and A_1 (.976) is not significantly different from 1 (z = 0.401).

Discussion And Conclusion

Many manufacturers and retailers use product warranties to increase the value of the product and influence customer preferences. In this paper we develop the concept of warranty premium and suggest a way to model and measure it.

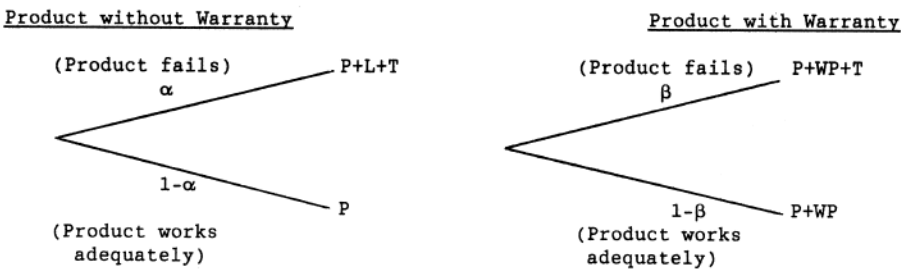
We define warranty premium and develop the concept in terms of the risk reduction role of warranties and the signal of quality that a warranty provides. Based on utility theory we derive an expression for warranty premium. The model is found to have good predictive ability in the experimental test conducted. The model and experimental study can help managers get a better handle on the value of the warranty to the consumer and how that is affected by the consumer's risk attitude, the cost of repair, the value of the consumer's time, and the signal of quality that warranty provides.

The paper provides a starting base for further research on warranty premium. There is clearly need for additional inquiry into warranty premium. One direction for future research is to decompose warranty premium into various components based on the expected loss, the risk attitude of the individual, and the quality signal that a warranty provides. A second direction is to further examine the impact on the warranty premium of the value of time and inconvenience of having the product repaired. A third area of research is to analyze the inferential processes by which consumers develop perceptions of the warranty-quality relationship and to examine how those perceptions can be impacted to increase the warranty premium.

An interesting finding of this study is that a significant number of people exhibited each risk preference: 50% were risk averse, 38% were risk prone, and 12% were risk neutral. These different risk attitudes may have been the result of the different ways in which individuals framed the warranty in their minds. A fourth area of future research is to examine how warranties can be framed and the impact of the framing on the warranty premium.

Since warranties are being increasingly used as a marketing tool by firms, a deeper understanding of warranty premium is very relevant and clearly warrants further research.

Appendix



For Risk-Averse and Risk-Prone Individuals

$$\alpha\, U(P+L+T) + (1-\alpha)U(P) = \beta\, U(P+WP+T) + (1-\beta)U(P+WP)$$

$$-\alpha e^{CP} e^{C(L+T)} - (1-\alpha) e^{CP} = -\beta e^{CP} e^{CWP} e^{CT} - (1-\beta) e^{CP} e^{CWP}$$

$$\alpha e^{C(L+T)} + (1-\alpha) = \beta e^{CWP} e^{CT} + (1-\beta) e^{CWP}$$

$$e^{CWP} = \frac{\alpha e^{C(L+T)} + (1-\alpha)}{\beta e^{CT} + (1-\beta)}$$

$$\text{Thus,}\quad WP = \frac{1}{C} \ln \left[\frac{\alpha e^{C(L+T)} + (1-\alpha)}{\beta e^{CT} + (1-\beta)} \right]$$

For Risk-Neutral Individuals

$$\alpha\,(P+L+T) + (1-\alpha)P = \beta(P+WP+T) + (1-\beta)\,(P+WP)$$
$$\alpha P + \alpha L + \alpha T + P - \alpha P = \beta P + \beta WP\ \ \beta T + P + WP - \beta P - \beta WP$$
$$\text{Thus,}\quad WP = \alpha(L+T) - \beta T.$$

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