Usage Heterogeneity and Extended Warranties

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The role of product warranty in segmentation of consumer durable product markets is highlighted. I demonstrate that consumer moral hazard and heterogeneity in product usage create variation in the valuation of product warranties by the different segments in the market. In this context, the firm, by offering a self-selecting menu of base warranty and extended warranties, satisfies the warranty demands of the various segments of the population. The consumer choice behavior prediction of the theory with regard to extended warranty is empirically validated with data from a survey of new car buyers.

1. INTRODUCTION

There is increasing evidence in the marketplace of the growing emphasis placed by firms on the marketing of extended warranties. Ten years ago, hardly any firm marketed extended warranties. Nowadays, firms (e.g., Ford, GM, Toyota, JVC, Apple, etc.) have whole divisions devoted solely to the management of these contracts. For instance, Ford reports profits in excess of $100 million from sales of extended warranties (Menezes, 1988).

The growing popularity of extended warranties in the real world is in stark contrast to the research literature. Day and Fox (1985) observe, ". . . *we could glean little insight from the literature into the nature of demand (for extended warranty) . . . .*" Apart from highlighting the general need for research in this area, they make the important point that the research effort needs to focus first on understanding the factors that generate the consumer demand for extended warranty. This view is shared by practitioners as well. Managers believe that extended warranties play an important role in customizing the overall product warranty package to an individual consumer. However, they

have little intuition for the factors that seem to create the differences in warranty demand across consumers and, hence, the need for customization of product warranty.

This paper provides an explanation for the consumer demand for extended warranties based on the idea of consumer heterogeneity in product use. The paper argues that variation in consumer usage habits of the product combined with consumer moral hazard creates variations in consumer willingness to pay for warranty and, hence, their demand for warranty protection. It is shown that a menu of product warranties helps the firm cater to the heterogeneous insurance demands while simultaneously obtaining price discrimination. Extended warranties are useful in the implementation of the menu of warranties. The consumer choice prediction of the theory with regard to extended warranties is validated with data obtained from a survey of new car buyers.

1.1 PROBLEM MOTIVATION

Consider a monopolist marketing a consumer durable to consumers who are interested in the purchase of a single unit of the product. The consumers differ in their usage of product. The following example illustrates this heterogeneity; Professor A and Professor B own identical Honda Accords. Professor A stays two miles from the campus. Professor B stays 25 miles from the campus. Both professors use the car for the same purpose, which is to get to work and back. These two consumers subject the product to vastly different levels of use. Other things being equal, greater use of the product translates to a higher likelihood of product failure.[1] Consumers being knowledgeable of this relationship between usage pattern and the probability of failure will evaluate their warranty requirements accordingly. We show in the paper that this relationship between usage and failure probability has significant implications for the design of base warranty and extended warranties.

Through investment in effort in the form of product maintenance, individual consumers can significantly alter the probability that the product works. However, the firm cannot observe their effort

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1. For another example, consider the usage of the washer-dryer by two different types of consumers. A family of five members as compared to a single individual. *Consumer Reports* (February 1991) data show a direct connection between the average number of laundry loads per week and the probability that the machine ever needs repair. The percentage of machines ever needing repair went up from 14% among those who reported an average of one to four laundry loads per week to 25% among those who reported an average in excess of eight laundry loads per week. Furthermore, this pattern was observed across brands consistently.

input and, hence, cannot contract on it. We consider this consumer moral hazard in the paper. It is well known that consumer moral hazard results in underinvestment by consumers in maintenance and care (e.g., Cooper and Ross, 1985). Consequently, the firm offering a warranty faces the likelihood of higher warranty redemption costs due to product failures created by consumer underinvestment in product care and maintenance. We examine the optimal warranty policy for the firm in this context. The essential tension in the model is between the incentive to offer warranty due to insurance demands created by usage heterogeneity and the distortion in warranty redemption costs created by consumer moral hazard. We demonstrate that the firm by an appropriate design of its warranty policies can address the warranty demands of the market while simultaneously providing incentives for consumers to invest in product maintenance. This policy is implemented through the use of extended warranties, in channel settings typical to most consumer durables. The research demonstrates clearly the role of product warranty in segmentation of typical consumer durable markets. The empirical validation of the consumer behavior prediction of the theory provides support for the explanation.

The rest of the paper is organized as follows: Section 2 provides a brief review of the literature. Section 3 describes the formulation of the problem in the agency theory framework and obtains the optimal policy. Finally, we conclude with a discussion of the results and possible directions for future research.

2. BACKGROUND LITERATURE

As indicated earlier, the academic literature on extended warranties is sparse. On the other hand, there exists a considerable literature on the topic of product warranty. The economic literature provides three principal motivations for the existence of product warranty.[2] The idea of warranty as an insurance instrument was first advanced by Heal (1977). The assumption that buyers (i.e., consumers) are more risk-averse than sellers implies warranties have a useful role to play in providing insurance to consumers against product failure. The idea that warranty could be a useful tool for the firm in conveying its product quality to consumers was spurred by developments in the area of asymmetric information. This signaling motivation (Akerlof,

2. The interested reader is referred to Lutz (1994) for a comprehensive survey of this literature.

1970; Spence, 1973; Grossman, 1981) predicts that firms that make better quality products will in equilibrium offer more comprehensive warranties. The incentive explanation for warranty was developed in contexts wherein agents (i.e., the firm and/or the consumer) affect product reliability through actions that are unobservable by the other. This theory (Cooper and Ross, 1985; Emons, 1988; Mann and Wissink, 1989) shows that a partial warranty by allocating losses from failure in some proportion to the agents provides the necessary incentive for them to invest in proper actions.

In the marketing context, researchers (Bearden and Shimp, 1982; Menezes, 1989) have studied the impact of product warranty on consumer attitudes, perceptions, and preferences toward the product. They report evidence for the role of warranty in mitigating the degree of risk perceived by consumers in purchase of a product. Wiener (1985, 1988) analyzes the empirical evidence for the signaling role of product warranty and the impact of the Magnuson-Moss FTC Act of 1975 on warranty practice. Menezes and Currim (1992) explore the problem of determination of the optimal length of product warranty. Boulding and Kirmani (1993) examine consumer perceptions of warranties in experimental settings and find that consumer responses seem consistent with the behavioral assumptions of signaling theory. Note that the focus of all the literature cited so far is on product warranty and not extended warranties.

Day and Fox (1985) report the results of a qualitative research study conducted with a view toward obtaining an understanding of consumer perception and decision making with regard to extended warranty. Based on their data and that of an MIT study conducted earlier,[3] they suggest that the following factors are likely to be related to the demand for extended warranties. Consumer risk attitudes are likely to be important because risk-averse consumers will desire greater warranty protection in comparison with others. Product usage is likely to be important in the sense that consumers who make greater use of a product are likely to desire greater warranty protection. Consumer experience with the product might influence demand for warranty protection because inexperienced users might desire greater warranty protection. Finally, they suggest that income might also influence demand for extended warranties although they are less sure of the directional nature of this effect.

Padmanabhan and Rao (1993) analytically characterize the optimal manufacturer warranty policy in the context of a market that is

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3. Center for Policy Alternatives (1978), MIT, vols. I–IV, CPA-78-14.

heterogeneous in risk preferences. Their work makes precise the conjecture of Day and Fox (1985) regarding the role of risk attitudes in influencing the demand for extended warranties. Their empirical analysis demonstrates that manufacturers, by increasing the length of the base warranty (thereby providing greater insurance at the time of purchase), can reduce the importance of risk aversion in influencing choice for extended warranty. Their estimates suggest that a base warranty of three years on automobiles makes risk preference an insignificant predictor of choice for extended warranties. That observation begs the question, What factors other than risk preference can explain the demand for extended warranties? Since consumers do purchase extended warranties on automobiles with three-year base warranty, there are clearly other factors that drive their behavior and the demand for additional warranty protection. The move by most auto manufacturers to a standard three-year/36,000-mile base warranty for 1992 models only serves to heighten the relevance of research aimed at addressing this question.

3. MODEL

In this section, we develop a model of a monopolist offering warranties to consumers who vary in terms of their usage habits of the product. We use the principal-agent framework in formulating the problem. The basic structure of the game is as follows: The manufacturer designs a menu of price and associated levels of warranty coverage. The consumer makes a decision with regard to purchase of the product and warranty coverage from this menu. The consumer then decides on the effort to be invested in product maintenance and care. If the product fails, the consumer collects on the warranty. The point of the paper is to show that a menu of warranties is indeed optimal when consumers are heterogeneous in their usage habits.

3.1 ASSUMPTIONS

We next outline the assumptions of our model.

ASSUMPTION 1: *The firm markets a product of known quality.*

We view quality in the sense of product reliability and assume that it is known to both agents. There exists a vast data base in the popular press on reliability ratings of most consumer durables sold in the market. Consumers have free access to this data base. Given this, and the fact that the focus of this paper is on extended warranties

and not as much the base warranty and its possible role as a signal of product quality, we feel that this is a reasonable assumption.[4]

ASSUMPTION 2: *The product usage of an individual consumer denoted by β is exogenously determined.*

Product usage is a function of host of factors such as household location, household size, socioeconomic circumstances, and related variables. In most situations, these variables are determined prior to the purchase of the product itself. It is difficult to visualize consumers controlling for family size, location, etc. based on considerations of product usage. The thrust of the paper is that these factors influence usage that in turn influences the demand for warranty protection.

We will use the following interpretation for β in the model. A low β represents a consumer who subjects the product to intense use, and a high β represents a consumer who subjects the product to light use.

ASSUMPTION 3: *The probability that the product works, π, is a function of the type of use that the product is subject to, β, and the amount of effort invested by consumer in product maintenance and care, e. We assume that $\pi(\beta, e) = \alpha_0\beta + \alpha_1 e$, where $\alpha_0 > 0$ and $\alpha_1 > 0$.*

In general, π will be a nonlinear function of β and e, concave in both effort and type, but we assume linearity for easier exposition. Clearly, the problem is meaningful only for $e < (1 - \alpha_0/\alpha_1)$. Note also that the quality of the product can be thought of as mapping into α_0. In our model, it represents the probability that the product works in the absence of any effort investment on the part of the consumer.

We have provided here an operationalization of usage heterogeneity that relies on variations in the probability of failure. There are clearly alternative methods for operationalizing usage heterogeneity. One approach is to model usage heterogeneity through variations in the valuation of a working product by the different consumer types, the idea being that heavy users obtain a greater monetary value from a working product than a light user, and, therefore, different consumers obtain different utilities from the product. Alternatively, it could be the case that heavy users incur a greater loss from the failure of the product. It can be shown that these alternative specifications of usage

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4. Note that all of the signaling literature focuses on the role of base warranty as a signal of product quality and not the role of extended warranties as a signal of quality. We believe that extended warranties have much more of a role to play as an incentive for provision of quality, given the sequence of events in the model. See Lutz and Padmanabhan (1994) for a discussion of this.

heterogeneity preserve the role of warranty in segmentation of a heterogeneous market. We discuss this in greater detail in Section 5.

ASSUMPTION 4: *The cost of effort e to the consumer is given by $\psi(e) = e^2/2$. The total utility of a consumer is separable in wealth and effort. Thus, $U(x, e) = U(x) - \psi(e)$ where $U'(x) > 0$ and $U''(x) \leq 0$.*

Effort is costly to consumers, and we assume that this cost increases with effort at an increasing rate. The functional specification that we use satisfies this convexity requirement. Note that the consumer investment in effort follows their decision with regard to purchase of the product and warranty. The second part of the assumption specifies separability of total utility over wealth and effort. The assumption is widely used in the literature (e.g., Holmstrom, 1979; Lutz, 1989). It is made for the purposes of analytical tractability. We also assume in our model that all consumers are identically risk-averse.

3.2 CONSUMER'S PROBLEM

Consumers buy a single unit of the product. Let p denote the price of the product and y denote the initial level of wealth of all consumers. The expected utility from the product is a random variable due to the probabilistic nature of product performance. For the sake of simplicity, we assume that the product can only be in one of two states: It either works or fails. Consumers enjoy a monetary benefit, v, if the product works. Let w be the warranty coverage on the product. The consumer receives the warranty payment w in case of product failure. The expected utility from the purchase for a consumer of type β is

$$EU(\beta, p, w) = \pi(e, \beta)U(y - p + v)$$
$$+ (1 - \pi(e, \beta))U(y - p + w) - \psi(e). \quad (1)$$

The consumer maximizes expected utility through choice of effort. The optimal effort $e^*(w, p, \beta)$ is

$$e^* = e^*(w, p, \beta) = \alpha_1[U(y - p + v) - U(y - p + w)], \quad (2)$$

where $e^*(w, p, \beta)$ denotes the optimal effort choice of an individual of type β for a product with warranty protection at level w.[5]

The participation of consumers requires that the expected utility from the purchase be at least as great as the utility derived from no

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5. Concavity of expected utility implies that $e^*(w, p, \beta)$ is unique. We will suppress the functional dependence of e^* on w and p for notational convenience in the rest of the paper.

purchase of the product, that is,

$$\pi(e^*, \beta))U(y - p + v) + (1 - \pi(e^*, \beta))U(y - p + w)$$
$$- \psi(e^*) \geq U(y). \quad (3)$$

The maximum price (reservation price) paid by the consumer for the product with the warranty, $p^*(w, \beta)$, is obtained when strict equality holds in eq. (3). In other words,

$$\pi(e^*, \beta))U(y - p^* + v) + (1 - \pi(e^*, \beta))U(y - p^* + w)$$
$$- \psi(e^*) = U(y). \quad (4)$$

It is easy to show that $p_w^* > 0$.[6]

3.3 FIRM'S PROBLEM

Consider initially the firm's problem in the context of a homogenous market of consumers. In this situation, the firm will charge the reservation price p for the product. Note that this price includes the price of the product and the warranty w bundled with the product. The price for the warranty alone can be obtained as $p(w, \beta) - p(0, \beta)$. The expected cost to the firm (which is assumed to be risk-neutral) of servicing the warranty is

$$C(w, \beta) = (1 - \pi(e, \beta))w. \quad (5)$$

The warranty profit maximization problem for the firm can be formalized as

$$\max_w R(w, \beta) = p(w, \beta) - p(0, \beta) - C(w, \beta). \quad (6)$$

It is easily shown that there exists a $w^* \in (0, v)$ that maximizes the firm's profit. This is the standard insurance result (e.g., Cooper and Ross, 1985; Padmanabhan and Rao, 1993), and we state it as a theorem for the sake of completeness.

THEOREM 1: *The optimal decision for the firm is to offer a warranty w^*, where $0 < w^* < v$.*[7]

Note that with consumer moral hazard, this level of coverage is always incomplete. This is important because it sets up a situation in

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6. In what follows from here, we will dispense with the * notation when referring to these quantities. All references to these quantities denote optimal choices unless otherwise specified.

7. Proofs of all the results are in a separate appendix, which is available upon request.

which the firm can profitably attempt segmentation through product warranty in a heterogeneous market.

3.4 HETEROGENEOUS CONSUMERS

Consider the situation in which the market is made up of two types of consumers: a low usage-type consumer denoted by β^l and a high usage-type consumer denoted by β^h (where $\beta^l > \beta^h$). Consumers know exactly the type of use they will make of their product. The firm has no way of identifying the consumer type during the course of the purchase process. However, the firm knows the distribution of consumer user types over the population. Let Δ denote the fraction of light users in the population. This is equivalent to saying that while the firm knows the different segments in the market and their respective sizes, it has no way of identifying the segment affiliation of a consumer during the choice process.

The following proposition demonstrates that variations in product usage create variations in the consumer valuation of the product warranty that are reflected in their reservation prices for the product + warranty bundle.

PROPOSITION 1: *The light usage-type (β^l) consumer is willing to pay more for the product with the warranty (i.e., $p(w, \beta^l) \geq p(w, \beta^h)$). The high usage-type consumer (β^h) is willing to pay more for the warranty alone (i.e., $p(w, \beta^h) - p(0, \beta^h) \geq p(w, \beta^l) - p(0, \beta^l)$).*

The result makes intuitive sense. The lower probability of failure for β^l-type consumer implies that the expected value of the gamble is higher, and, hence, they are willing to pay more for the product and warranty bundle. However, since they are willing to invest in more effort and self-insure, the price that they are willing to pay for the warranty alone is lower. The variation in reservation prices has direct implications for the optimal level of warranty coverage that is offered to each consumer type, and this is formalized next. Let w^h and w^l denote the optimal levels of warranty coverage for the β^h- and the β^l-type consumer, respectively.

PROPOSITION 2: *Other things being equal, the warranty coverage offered by the firm to the individual increases as usage increases (i.e., $w^h > w^l$).*

Low usage types prefer higher self-insurance, and the firm offers a lower level of warranty coverage to these consumers. The propositions highlight the fact that heterogeneity in product usage and consumer moral hazard combine to create variations in the prices that different consumers are willing to pay for the product, which in turn

has implications for the optimal warranty coverage for the different consumers. Taken together, these results provide the necessary intuition for the price discrimination strategy that can be adopted by the firm and the role of product warranty in its implementation.

The firm satisfies the warranty requirements of the low usage-type consumers by ensuring that the product is bundled with this lower level of warranty. The additional warranty requirements of the high usage segment is met through the provision of an optional extended warranty. Let p denote the price of the product and w denote the level of warranty coverage provided with the product. Let t denote the price of the optional extended warranty and s denote the coverage provided by the extended warranty. The firm ensures that the prices are set in such a way that all consumers buy the base product warranty bundle, and the high usage-type consumers purchase the optional extended warranty. The appropriate prices are obtained from the relevant incentive compatibility conditions for the different consumer types. They ensure that the product warranty bundle is a better choice for the low usage types compared with no purchase or the choice of the product and the extended warranty and the product + extended warranty is a better choice for the high usage types compared with no purchase or the choice of product alone.

The profit maximization problem faced by the firm can then be represented as follows: Note that the effort e and the reservation price p refer to the optimal quantities as obtained from eqs. (2) and (4) for the different consumer types.

$$
\max_{p,w,s,t} \Delta[p - (1 - \pi(e(w, \beta^l)))w]
$$
$$
+ (1 - \Delta)[p + t - (1 - \pi(e(w + s, \beta^h)))(w + s)], \quad (7)
$$

subject to

$$
EU(\beta^l, p, w) \geq \max[U(y), EU(\beta^l, p + t, w + s)], \tag{8}
$$

and

$$
EU(\beta^h, p + t, w + s) \geq \max[U(y), EU(\beta^h, p, w)]. \tag{9}
$$

We can use the earlier results to simplify the self-selection constraints (8) and (9) and solve the problem. The intuition for solution can be easily obtained from Figure 1. Recall that $p(w, \beta^l) > p(w, \beta^h) \forall w \in [0, v)$. Therefore, any product warranty bundle that satisfies the participation constraint of the heavy users will provide greater than reservation utility for the light users. Note also from Figure 1 that for any combination $(p(w, \beta^l), w)$, the high usage types are willing to pay more for additional warranty coverage than low usage types. This
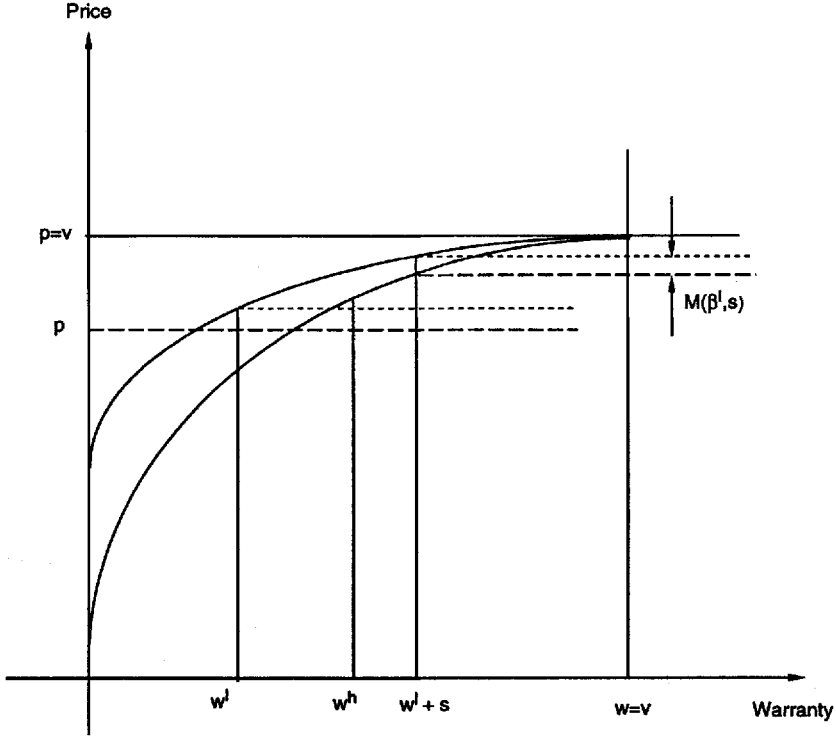
Price

FIGURE 1.

simplifies the maximization problem to the following Lagrangean:

$$L = \max_{p,w,s,t} \Delta[p - (1 - \pi(e(w, \beta^l)))w]$$

$$+ (1 - \Delta)[p + t - (1 - \pi(e(w + s, \beta^h)))(w + s)]$$

$$+ \mu_1[EU(\beta^l, p, w) - EU(\beta^l, p + t, w + s)]$$

$$+ \mu_2[EU(\beta^h, p + t, w + s) - U(y)].$$

The solution to the monopolist's problem can be obtained directly from this formulation (where μ_1, μ_2 are the auxiliary variables). The intuition for the optimal solution is briefly sketched here. Recall that the low valuation consumer is always willing to pay a higher price for the product warranty bundle. This implies that the warranty coverage provided by the manufacturer to light users will be the optimal level of coverage (i.e., $w = w^l$). In other words, the manufacturer will not distort the warranty provision to light users in the heterogeneous

market. Note that the differences in reservation prices between the two types decrease with increase in warranty coverage. This suggests that the manufacturer can reduce the rents paid to the low usage type by increasing the level of coverage provided to the high types. This rent reduction motive implies that the manufacturer can and will distort the warranty coverage provided to the high types. In other words, the total coverage provided to the high types will be strictly greater than the optimal warranty coverage for them (i.e., $w^l + s > w^h$). The formal solution of the Lagrangean is characterized in the following theorem:

THEOREM 2:   *The optimal policy is implemented by (1) marketing the product with a base warranty offering w^l level of warranty coverage at a price $p(w^l, \beta^l) - M(\beta^l, s)$, and by (2) marketing an optional extended warranty that offers s level of warranty protection at a price $p(w^l + s, \beta^h) - p(w^l, \beta^l) + M(\beta^l, s)$.*

   The rent paid to the light users is denoted by $M(\beta^l, s) = p(w^l + s, \beta^l) - p(w^l + s, \beta^h)$ and is a function of the level of overinsurance of the heavy users. The actual level of overinsurance is a function of the Δ, which is the proportion of light users in the population. The screening solution advanced in the paper is sensitive to the relative profit contributions from the insurance contracts marketed to the two different types of consumers. The profits from the coverage offered to high usage-type consumers will decrease as their usage gets more intense. Additionally, the losses from payment of rents to light users outweigh the profits from warranty to heavy users when there are too many light users in the market. At some point (depending on the sizes of the two segments and the relative profits), the profits from catering to the insurance demand of both segments will start diminishing compared with a policy that focuses solely on the light users. If a sufficiently large proportion of the population consists of light users, then the firm in fact will find it optimal not to offer a menu of warranty options. It will offer only one product with w^l level of coverage at $p(w^l, \beta^l)$. This policy effectively excludes the heavy users from the market. The policy of exclusion of warranty privileges to commercial users of washer-dryer units is one example of this phenomenon. The use of abuse clauses in warranty terms or the use of mileage limits on warranty provision are other examples of this effect. Note that this result of exclusion of certain types of consumers by the firm is similar to some of the work done in the sales force compensation literature. The focus there is on situations where the firm is strictly better off by excluding some of the less efficient salespersons from the sales force (see Lal and Staelin, 1986; Rao, 1990).

To summarize, the firm markets the product with a base warranty at the price that the light user is willing to pay for the product. The level of coverage provided by the base warranty is the optimal level for the light user segment of the population. The firm markets optional extended warranties that are of interest to the heavy-user segment of the population.[8] The suggested warranty policy in the paper closely reflects the current market reality. Most manufacturers of consumer durables offer consumers a menu of optional extended warranties of various types to choose from after the purchase of the product. Ford offers more than 100 extended warranties that vary in terms of their deductibles as well as in terms of their coverage as a function of time and mileage. For example, a consumer, after purchasing a Ford automobile with a three-year/36,000-mile base warranty, is offered a menu that features among other possibilities a five-year/50,000-mile extended warranty with a $50 deductible, $100 deductible, or a $250 deductible as well as a five-year/50,000-mile extended warranty, six-year/75,000-mile extended warranty, or a seven-year/100,000-mile extended warranty with the same deductible. This is just a subset of the possible items in the menu. This assortment is virtually identical for other makes and models of automobiles. The situation is almost identical for other consumer durables such as washers, dryers, refrigerators, as well as standard home electronics products.

4.   EMPIRICAL ANALYSIS

The theory provides normative implications for warranty policy. It also makes clear predictions regarding expected consumer behavior particularly with respect to choice of extended warranty. It predicts that heavy users of the product will purchase extended warranties and light users will not. We will assess the validity of this prediction with data from a survey of new car buyers. Admittedly, this test is at best a partial test of the theory, but at the very least it does provide an opportunity for the rejection of the theory. In a further attempt to strengthen the test of the theory, we also assess the validity of competing plausible explanations for the use of extended warranties.

4.1   DATA

The product category chosen to test the theory was automobiles. The data were obtained by a mail questionnaire. Information was obtained

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8. Note that the firm's strategy will not change qualitatively even if the usage information is obtained at the time of selling the product.

from individuals on their decision with regard to extended warranties, their usage habits, expected length of ownership, and standard demographic information. The questionnaire was mailed to 2,400 new car buyers in the Dallas-Fort Worth Metroplex area. A total of 612 replies was obtained for a response rate of 25.1%. The response rate is consistent with the response rate for most single mail-out studies (Dillman, 1978). The data base used for testing the theory was car models that offered a standard three-year/36,000-mile base manufacturer warranty. Some of the car makes included in the data base were Acura, Cadillac, Chevrolet, Escort, Honda, Oldsmobile, Taurus, and Toyota. A three-year/36,000-mile base warranty is the de facto market standard now. Assessing the validity of our model with that data set including makes featuring other base warranties (e.g., one-year/12,000-mile) would provide no evidence of the fit of our theory with the current market reality. Additionally, only consumers who indicated that they planned on owning the car longer than three years were included in the analysis. The data set had 178 observations.

4.2 ESTIMATION AND RESULTS

We test the validity of the consumer behavior predictions of the model using a binary probit model. The model used for specifying the utility derived by a consumer from an extended service contract relative to buying the product without an extended warranty is

$$U = \gamma_0 + \gamma_1 * DUSE_i + \gamma_2 * CPRICE_i + \gamma_3 * MSTATUS_i$$
$$+ \gamma_4 * INCOME_i + \gamma_5 * LENGTH_i + \gamma_6 * PRISK + error. \quad (10)$$

The dependent variable in the probit regression is the consumer decision with regard to choice of a service contract denoted by BUY_i. It takes the value one if the consumer purchased a service contract and zero otherwise. The intensity of product use is operationalized in this context with the use of another binary variable $DUSE_i$. The questionnaire required the respondents to indicate whether they used the vehicle primarily

1. for business purposes.
2. to get to work and back.
3. other (please specify).

The variable $DUSE_i$ was set at one if the consumer indicated that the vehicle was used primarily for business purposes and zero

otherwise. This representation of usage intensity is consistent with the automobile insurance industry treatment of usage intensity, which is based on estimates of annual mileage associated with various uses. Readers who have requested an insurance quote will recall that among the questions asked by the insurance agent is the type of use of the vehicle. In economic terms, insurers are using product usage as one of the underwriting characteristics to screen consumers without needing to consider self-selection constraints. The insurance industry estimates that the consumer who uses the car primarily for business purposes logs an average of 15,000–20,000 miles per year compared to an average of 9,000–14,000 miles for other users. We believe that the annual mileage provides a good measure of the intensity of use of the automobile. In fact, we believe that this is one of the primary reasons for firms specifying typical warranties on the basis of two variables (years and miles of coverage) as opposed to simply one (i.e., solely based on years of coverage). We expect that the coefficient γ_1 will be positive and significant.[9]

We include three other variables that prior research (Bryant and Gerner, 1982; Day and Fox, 1985; Padmanabhan and Rao, 1993) suggest are likely to be significant in influencing the choice for extended warranties. They are $CPRICE_i$, which denotes the price paid by the consumer for the automobile; $MSTATUS_i$, which denotes the marital status of an individual; and $INCOME_i$, which denotes the annual income. The argument for inclusion of $CPRICE_i$ is that this measures in some sense the value of the product. Therefore, consumers will be more likely to purchase insurance on products that are more valuable. The argument for inclusion of $MSTATUS_i$ is driven by the thesis that single individuals due to lower product experience, lower income, and lower age are more likely to value insurance. The argument for inclusion of $INCOME_i$ is the fact that higher-income individuals have a higher value of time.

We include $LENGTH_i$ (which denotes the consumer's expected length of ownership of the vehicle) to assess the validity of a compet-

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9. It is possible to argue that the empirical operationalization of usage heterogeneity through business use of automobiles creates a possible confounding effect. Individuals who purchase an automobile solely for the purpose of business use can write off the price of the car as well as the extended warranties as a tax deduction. This could create a tendency for business users to purchase extended warranties purely because of the tax write-off. However, we do not feel that this is a reasonable argument for the choice of extended warranties. If business use of automobile qualifies as a deduction, then maintenance and repairs of the automobile also qualify for tax deductions. If the cost of repairs looms larger to an individual than the price of extended warranties, then it would actually make more sense to the business person to not purchase the extended warranties.

ing explanation for use of extended warranties based on consumer heterogeneity in the expected length of ownership and $PRISK_i$ (which denotes the consumer's risk preference to assess the validity of a competing explanation for use of extended warranties based on variation in risk preferences[10]). A theory based on the idea of variation in length of ownership would predict that firms would use extended warranties as a screening mechanism and the consumers who plan on using the car for longer periods of time will purchase the extended warranties and the others will not. A similar development for the role of extended warranty as a screening mechanism in the presence of risk preference (Padmanabhan and Rao, 1993) would predict that risk-averse consumers will purchase the extended warranties and others will not. The results of the probit regression are shown in Table I.

The coefficient γ_1 that measures the impact of usage heterogeneity on the choice behavior of consumers with respect to extended warranties is positive ($\gamma_1 = 1.50$) and significant. This is the relationship predicted by the theory. Essentially the theory argues that extended warranties have a useful role to play in helping the firm address the segmentation issues created by variations in consumer demand for warranty protection due to heterogeneity in usage habits. The self-selection feature of warranty policy ensures that intense users of the product will purchase the service contract. Light users will find the protection offered by the base warranty to be adequate and, therefore, will not purchase the optional service contract. The data is consistent with this explanation and thereby provides credence to the validity of the theory.

The data indicates that $CPRICE_i$ ($\gamma_2 = 0.00004$) has the expected impact on the utility derived from a service contract. Consumers obtain greater utility from extended warranties on higher priced vehicles. The impact of income is also in the expected direction ($\gamma_3 = 0.000009$) with higher-income individuals finding extended warranties to be more attractive. The results also indicate that marital status has a significant impact on the utility derived from extended warranties ($\gamma_4 = 0.97$). Singles derive far greater utility from these contracts com-

10. Consumers' risk preference was ascertained by their response to lottery questions. One of the questions was as follows: Mr A has planned a vacation with his family. The total cost of the trip is $3,000. The weather center reports a 5% chance of bad weather that could result in cancellation of the trip. In that case, Mr. A would lose all the money. Travel insurance that guards against this loss is available. If the insurance was available at each of the following prices ($100, $150, $200, $250, $300), should Mr. A purchase it? If respondents indicated that Mr. A should be willing to pay a price for insurance that was less than the expected value of the lottery, then $PRISK_i$ was set at zero for that respondent; otherwise it was set at one.

Variable	Coefficient	Chi Square	P
DUSE	1.50	4.09	0.04
CPRICE	0.00004	5.71	0.02
INCOME	0.000009	2.13	0.14
MSTATUS	0.97	13.38	0.003
LENGTH	0.36	2.79	0.09
PRISK	0.16	0.60	0.43

Model chi-square = 43.38 (0.0001).

pared with married individuals. These results are consistent with prior research of Bryant and Gerner (1982), Day and Fox (1985), and Padmanabhan and Rao (1993). The coefficient γ_5 that measures the impact of length of ownership of the vehicle on choice behavior for extended warranties is positive (0.36) and insignificant at the 10% confidence level, and the coefficient γ_6 that captures the impact of risk preference on choice behavior for extended warranties is positive (0.16) and insignificant.[11]

5. CONCLUSION AND DISCUSSION

This paper develops a theory for the role of product warranty in segmentation, and it demonstrates that heterogeneity in consumer usage habits and consumer moral hazard creates variations in consumer reservation prices and in their demand for warranty protection. It shows that the firm can effectively address this heterogeneity through the use of a menu of optional extended warranties. This paper represents a useful contribution to the growing literature on the topic of product warranty and extended warranties. It analytically validates the conjecture of Day and Fox (1985) regarding the role of usage heterogeneity in influencing the demand for extended warranties. It complements the work of Padmanabhan and Rao (1993) by demonstrating that even in the absence of heterogeneity in risk preferences, there

11. Given the result on insignificance of risk aversion, one might wonder if the screening result of product warranty would hold in a market where consumers are risk-neutral. In fact, they do extend easily to this setting, suggesting that the screening argument for extended warranty is fairly robust.

exists a motivation for the use of extended warranties as a segmentation variable.

We would like to address briefly issues regarding the assumptions made in the model development and the implications of relaxation of some of these. The paper assumes that all consumers are identically risk-averse and models usage heterogeneity through variations in the probability of failure of the product. There are clearly alternative methods for specifying usage heterogeneity. One approach is to model usage heterogeneity through variations in the loss suffered by consumers in the case of product failure.[12] Presumably, heavy users incur a greater loss from failure than light users due to opportunity costs and the downtime of failure. Another approach is to model usage heterogeneity through variations in the valuation of a working product by the different consumer types, the idea being that heavy users obtain a greater monetary value from a working product than a light user. It is relatively easy to show that these alternative specifications of usage heterogeneity do not change the essential intuition of our model and present qualitatively identical results with regard to the use of extended warranties as means to segment consumers.[13] Similar results are obtained if we allow high-usage consumers to be more risk-averse than low-usage consumers. The problem gets more complicated if we allow for multiple specifications of usage heterogeneity in the same model.[14] This makes the problem more interesting but also makes the analytics quite intractable.

The other major assumption in the model involved characterizing the market as a monopoly. We believe that this is a reasonable assumption especially in the context of the automobile market. The choice of an extended warranty is made after the purchase of a product. The majority of extended warranties purchased by consumers are done so at the point of purchase of the product. Therefore, the consumers are restricted in their choice to the extended warranties carried by the retailer. If there is any competition in the market, it is between the manufacturer and other third-party companies in getting

12. The modification of the model is simple. We assume that failure creates a loss k. Consequently, the monetary valuation in case of product failure is $y - p + v - k$, and the warranty payment is modeled unchanged.

13. The easiest way to see this is to notice that comparative statics results of reservation price and effort with regard to alternative consumer type specification are identical (i.e., $dp/dv = dp/dk = dp/d\beta \geq 0$). These comparative statics drive the results in the paper.

14. For instance, allowing for probability of failure as well as the utility derived from the product to be dependent on usage patterns of the product.

the retailer to carry their service contracts. The vast majority of auto-
mobile dealers carry only a single line of extended warranties backed
either by the manufacturer or a third-party insurance company. As a
consequence, as far as the consumer is concerned, he or she is still
faced with a monopolistic situation with regard to the purchase of
optional warranty protection. For the most part, automobile dealers
carry the manufacturer-backed extended warranties, whereas in the
home appliance and home electronics product categories, the major
retailers (e.g., Circuit City, Good Guys, etc.) carry their own extended
warranties. Given these facts, we believe that the monopoly assump-
tion is not unduly restrictive.

There are several promising directions for future research in this
area. From an institutional perspective, the warranty menu prescribed
by the theory is currently administered by an individual sales agent
at the retail outlet. These sales agents can often obtain reasonably
diagnostic information about consumer type during their interaction
with the consumer. The firm is clearly better off if it were to have
access to this information on consumer types and/or if the warranty
contracts presented to the consumer by the sales agent were based
in the light of this information. Therefore, it would be interesting to
explore how the firm can design its sales force compensation contracts
so as to provide them with the necessary incentive to gain and reveal
this information. For instance, what variables might such a compensa-
tion contract rely on that reduce the informational rents paid to the
consumers associated with the warranty transaction as well as the
sales agent? The influence cost theory of Milgrom (1988) and Milgrom-
Roberts (1988, 1990) as well as the literature on organizational hier-
archy (von Hayek, 1945; McAfee and McMillan, 1994) would be the
logical starting point for such an exercise. On the empirical side, it
would be useful to obtain data on warranty practice across a cross
section of firms to understand practice and differences in practice as
functions of variables such as distribution of risk preferences, usage
habits, demographic variables, and other relevant variables. On the
theoretical side, the model assumes that consumers are informed
about product quality. Explicit modeling of quality differences among
producers in competitive markets and studying their impact on war-
ranty practice in the face of uninformed consumers would be of con-
siderable interest. The growth in the number of third-party purveyors
of extended warranties raises the question of what should be the opti-
mal manufacturer policy with regard to base warranty and extended
warranties given competition in this sense. It would also be interesting
to examine warranty practice across product categories to understand

better the role of warranty and its interactions with product value, knowledge, familiarity, and experience.

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