Consumers' perception of a warranty as a signal of quality: An Empirical study on the automobile industry

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1 Introduction

In recent years, several automobile companies have changed the warranties on their cars, and, after the change, have seen their market share change significantly. For example, in 1999 Hyundai Motors extended their power train warranty from 5 years and 60,000 miles to 10 years and 100,000 miles. In subsequent years, Hyundai's U.S. market share increased from 1.1% to 4%. In another example, Dodge saw a 5% increase in sales after changing their warranty in the time period between November 2001 and July 2002. These are just a few examples of firms that have introduced longer warranties in recent years. Yet, there are also firms that have reduced the length of warranties. In 2002, Volkswagen reduced the power train warranty on their vehicles from 10 years/ 100,000 miles to 5 years/ 60,000 miles. In the 3 years after the warranty change, sales of Volkswagen cars in the U.S. declined 30%. These examples suggest a high level importance of warranty coverage in the demand for automobiles. This naturally raises the question: do consumers consider a warranty as a signal of product quality, as theorized in the economic literature?

Although there are many theoretical papers that consider warranties and signaling, only a few papers empirically examine warranties as a form of signaling.[1] Several reasons may explain why there are relatively few empirical studies in this field. One reason might be the lack of a data set that contains various types of product characteristics and manufacturer information along with consumer information. Another reason might be due to the difficulty in measuring intangible concepts, such as signaling, risk aversion, moral hazard, and adverse selection. Measuring these concepts in information economics requires a detailed empirical model of consumer behavior.

The automobile industry is a natural candidate for an empirical study in information economics not only because of recent changes in warranty terms, but also because of readily available data for this type of research. Another benefit of analyzing the automobile

[1] Riley (2001)says "Despite the plethora of theories arguing that introductory prices, advertising, and warranties can signal high quality, there is remarkably little applied work seeking empirical support".

industry is the existence of well developed econometric specifications that directly model consumer utility.[2] In this paper, a conditional logit model is used to describe consumer behavior with consumer level data from the *Consumer Expenditure Survey*. Several data sets from *Automotive News, Consumer Report* and *Warranty Direct*, are used to to measure the degree to which warranties affect choice as a signal. The major contribution of this paper to the existing literature is the use of a discrete choice model and consumer level data set to study information economics.

The results of this paper indicate that a warranty increases the likelihood of a product being chosen. This paper also tries to distinguish between the two possible explanations for the increased likelihood, signaling and risk aversion. Estimation results show tha weak support of risk aversion motive for warranty but do support the signaling motive.

2 Signaling and warranty

Among the theories about the role of information in economics, adverse selection and moral hazard show how asymmetric information can complicate market operation.[3] Signaling theory argues that some informed agents may try to reduce asymmetric information by sending signals to uninformed agents.[4] Warranties are considered a common type of signal sent by "high quality" firms to reduce the consumers' informational gap on the quality of their products. With the assumption that offering a warranty is more costly for firms producing "low quality" products, a warranty can be a credible signal of product quality. In the automobile industry, such an assumption clearly holds. Product failures are correlated to the quality of products. Therefore, the cost of offering a longer warranty for a low quality

[2]See Goldberg(1995), Berry(1994), Berry, Levisohn, and Pakes(1995), Brownstone and Train(1999), and Train and Winston(2004)

[3]Akerlof(1970)[3] shows that lack of information might hinder a function of markets.

[4]Spence(1977)[11] argues that signaling will facilitate the function of market when there is lack of information under the assumption that market is perfectly competitive, and Grossman(1981)[8] find the similar result with more relaxed assumption on the market (single supplier). Gal-Or(1989)[12] focuses on duopoly market and argues possibility of multiple equilibriums.

car will be high. This makes the automobile industry a suitable industry for empirically testing the use of warranties as a signal.

However, based on both a firm's warranty and the consumers' response to the warranty, several different types of equilibrium may exist. First, a separating equilibrium exists when firms have different types of warranties based on the quality of their products, and consumers interpret the warranty as a signal. Consumers perceive and update their prior beliefs of product quality with the presence of a warranty. Another equilibrium is a pooling equilibrium, where firms offer the same warranty regardless of their product quality and consumers can not distinguish the quality of products. Based on producers' and consumers' behavior either types of equilibria can exist.

A warranty is only effective as a signal in a separating equilibrium. There are several necessary conditions for a separating equilibrium. First, all firms know that a longer warranty is expensive for firms which produce "lower quality" products and all firms offer different levels of warranties based on product quality (durability). The second condition is that consumers should consider a longer warranty as a signal of higher product quality. The first condition holds in the automobile industry as the cost to firms of offering longer warranties depends on product quality. In the empirical information economics literature, research has focused on firm behavior.[5] Consumer perception of warranty, however, has not been as well studied. This paper mainly focuses on how consumers perceive a warranty.

There are two distinct reasons consumers may prefer a longer warranty. First, consumers may consider warranty as a signal of quality because they know warranties are costly to offer. In the case of durable goods where consumers do not have full information on quality, consumers may rely on the offer of warranties to make more informed decisions. Second, consumers might prefer to buy a product with a longer warranty because they are risk averse. In this case, a warranty is insurance against product failure. With an assump-

[5]For example, Jin and Leisle(2003)[9] study how posting hygiene quality grade cards in a restaurant changes consumers behavior by using restaurant revenue data rather than consumer side data.

tion that consumers are heterogenous in risk aversion, more risk averse consumers prefer a longer warranty as it reduces the risk of product failure. These two reasons show that a warranty may be effective not only because a warranty reduces the informational gap between producers and consumers, but also because a warranty acts as an insurance policy against product failure.

Producers also have analogous reasons for offering a warranty. First a firm producing "high quality" products has an incentive to send a signal to distinguish their products from other "medium or low quality" products. Since the firms producing high quality products know that it is expensive for firms producing "low quality" products to offer such a warranty, only firms producing high quality products might be able to distinguish themselves by offering a longer warranty. This is especially true in a durable goods market such as automobiles, since product failure is a probabilistic function of durability. Second, firms might consider a warranty as a type of profitable insurance. A firm can hedge the risk that consumers are not willing to take over all the products that they sell. Since a firm can not determine the risk tolerance of a consumer, such a hedge allows them to offer a warranty that will capture the demand of consumers that are extremely risk averse.

In an empirical study, directly controlling for consumer risk aversion is not practical due to the lack of suitable data. Suitable data would include expected utilities from both cases, when products fail and when products work well, and the associated risk premiums. However, showing whether or not consumers reveal a strong risk aversion against product failure is possible with a stringent assumption that all consumers are consistent in responding to all types of risks. With such an assumption, one way of observing consumer risk averseness is to use consumer insurance expenditures on other matters such as car liability, life, or property. Such insurance expenditure variables might act as a proxy for consumer risk aversion. If consumers reveal the same risk aversion against product failure and financial loss, consumers who spend more on other types of insurance are relatively more risk averse, and therefore would prefer to have a longer product warranty relative to consumers with less risk aversion.

With the assumption that product failure is a function of product quality (durability), consumers have limited information about quality when they buy a certain product. While making a purchase decision, consumers use their prior information of product quality, as it can not be directly observed before purchase. In this sense observing possible information that could affect a consumer's prior information is critical in analyzing the effect of warranty as a signal. Prior information might come from several sources, including their own past experience, information from friends or relatives, magazine, and news. Thus, sources of information can be separated into two categories, private and public sources. Private sources are sources that not generally available to the public, for example their past experiences and information obtained from friends and relatives. Public sources are sources generally available to the public, for example magazines, news, and advertisement. Among those, magazines and news share common features in the sense that third parties are distributing the information, while advertisements convey information directly from producers. Information from both private and public sources affects consumers' perceptions of product quality and product choice. The information accumulated aids a consumer in forming prior beliefs of product quality.

In an empirical study, it is almost impossible to directly observe prior beliefs that affect consumer decisions on purchasing a certain product. Although individual consumers might have totally different prior beliefs about the quality of available products, there might be some common belief about quality of certain brands, for example, the durability of Toyota. Some of those common prior beliefs of products may be controllable by brand fixed effects. In addition, this paper tries to control for the information that consumer can obtain. Following Train and Winston (2004), car brands currently owned by consumers are used in order to control for consumer information from direct experience. Such a variable might be able to control how their own past experience affects a consumers' product choice, in a sense, brand loyalty. As Train and Winston point out, if unobserved consumer preference is correlated with the products they have chosen in the past and their current choice, the coefficient of brand loyalty variable might capture the unobserved consumers' preference

along with how consumers' product choice is influenced by past experience. Therefore, the coefficient of the brand loyalty variable captures both effects: unobserved consumer preference and information from past experiences. In this paper, brand fixed effect is also used to control for unobserved consumer preference for a certain brand along with brand loyalty variables.

Car ratings from *Consumer Reports* are used to control for information that consumers can obtain from public sources. The rating of cars can also be considered common perception since the rating is a result of consumer surveys. *Consumer Reports* compute their ratings based on surveys of consumers who have purchased and used certain products, and therefore generally exclude new products. Since *Consumer Reports* ratings are based on surveys, they can be considered a proxy for general perception of product quality. The fact that *Consumer Report* does not report all car models might be used to determine whether warranties increase information available to consumers. Consumers might value on information about lesser known products more than the information about a well known product. For example, if consumers know the durability of Toyota Camry well enough and do not have much information about the durability of the newly introduced Toyota Matrix, the value of information for the Matrix might be higher than for the Camry. In this sense, the value of a signal sent by warranty might be more for less known products than well known products

3 Data and Empirical Specification

3.1 Data

The Consumer Expenditure Survey (CES) [1] from 1998 to 2002 is used to model demand. The CES is made up of quarterly surveys which retain 75 percent of the original respondents in the next wave, while replacing 25 percent of the sample with new individuals. In each quarter of 1998, approximately 4500 households were surveyed, with the sample size

of each quarter increasing to 7000 in 1999. Thus, the total number of observed households is 52,361. Of this full sample 1,173 people bought new cars. In addition to individual characteristics, insurance expenditure variables are also extracted from CES data.

Data from *Automotive News* is used to collect data on product characteristics. The main product characteristics include price, engine size and length of car. Product characteristic data from Automotive News contains automobile characteristics at the trim level. For example, the Ford Focus has four different trim levels: 3-door, 4-door, 5-door, and wagon. The trim level data does not match perfectly with CES data since the CES data only reports model name and brand name. Therefore a certain level of aggregation is inevitable. In this paper, I aggregate product characteristics at the model level. So the characteristics of a Ford Focus will be the mean of those four trim level products. In the *Automotive News* cars are categorized into 7 finer classes which describe the size a vehicle may fall under: budget, small, entry-medium, medium, large, sporty, and luxury. All those 7 car classes will be included in this study. Information regarding changes in warranties are collected from Warranty Direct [6]. The *Consumer Reports*[2] data set is used for car ratings.[7]

3.2 Vehicle choice model

Assuming that the majority of households do not purchase a new car in a given year[8] and households that do purchase a new car buy only one car in a given year[9], vehicle choice is considered within a discrete choice model framework. This model follows Goldberg's (1995) model with a slight modification to consider whether or not consumers take a warranty as a product quality. For computational simplicity, a conditional logit model is used rather than a nested logit which is used in her paper. The cost of using a relatively simple conditional logit is the lack of a flexible substitution pattern due to the assumption of Independence of Irrelevant Alternatives (IIA). The conditional logit result will, however, still be consistent

[6] An internet based company selling extended warranties

[7] Summary statistics are reported in appendix

[8] From CES data, about 10 % of householders buy new car

[9] There are no observations of households who buy more than two new cars in the same year

when appropriate fixed effects are used.[10] In this paper, car class fixed effects are used. Although these two fixed effects are used as nesting structures in Goldberg (1995), in this model the fixed effect capture consumers' unobserved utility from choosing a certain car class. I assume that consumers maximize utility given some information, so that the indirect utility function of a consumer who buys a new car can be written as

$$U_{ij} = \bar{V}_{ij} + \varepsilon_{ij} \tag{1}$$

where i indicate a householder $i = 1, 2, ..., I$, j indicates choice of product $j = 0, 1, ..., J$[11], U_{ij} indicates a consumer i's indirect utility from a product j, and ε_{ij} indicates the consumer's unobserved utility from products. The deterministic component of the utility function can be expressed as product characteristics excluding price (Z_j), consumers' information about a certain product (X_{ij}), and warranty variables and a price variable interacted with income (W_{ij}).

The deterministic part of the utility function can be written as

$$\bar{V}_{ij} = \alpha' Z_{ij} + \beta' X_{ij} + \gamma' W_{ij} \tag{2}$$

where α, β, and γ are sets of parameters to be estimated. The product characteristics are similar to previous vehicle choice models.[12] In this paper, three different product characteristics are used: displacement (DISP), length (LENGTH), and warranty (WT) interacted with car class dummy variables. The variables for consumers' information (X_{ij}) include consumers past experience about certain products and possible information sets that consumers might have. The variables of information that might affect consumers utility are ratings (RATE) from *Consumer Reports*. The matrix (W_{ij}) includes a set of variables that indicate consumers' preference for warranty and price variables. A new variable price variable is

[10] This paper focuses on finding the impact of the warranty as a signal rather than finding detail consumption patterns such as elasticity. Therefore, a conditional logit will be sufficient for testing the existence of a signal by warranty, as the estimates would be consistent.

[11] when $j = 0$, the consumer chooses to not to buy a new car. In this case the utility of not buying a new car is assumed to be zero.

[12] See Goldberg(1995)[7], Berry(1994)[5], Berry, Levison, and Pakes(1995)[4], Brownstone and Train(1999)[6], and Train and Winston(2004)[13]

constructed by subtracting the price of a vehicle (P_j) from the income of consumers (Y_i). Using this variable rather than just the price allows me to take into account differences in consumers' income. The warranty variables consist of interaction terms between a warranty (WT) and other variables, a dummy variable ($NORATE$) that indicates nonexistence of a car ratings on *Consumer Reports* and a set of dummy variables that indicate consumers' different level of risk averseness.

The indirect utility function, equation (1), can be rewritten as

$$\begin{aligned}\bar{U}_{ij} &= \alpha_1 LENGTH_j + \alpha_2 DISP_j + \sum_{class} \alpha_{class} WT_j * D_{class} + \beta_1 EXP1_{ij} + \beta_2 EXP2_{ij} \\ &+ \beta_3 RATE_j + \beta_4 NORATE_j + \gamma_1 NORATE_j * WT_j + \gamma_2 (Y_i - P_j) \\ &+ \sum_{ra} \gamma_{ra} WT_j * D_{ra} + \xi_{class} + \varepsilon_{ij} \end{aligned} \tag{3}$$

where α, β, γ and ξ indicate coefficients for product characteristics, information sets, warranty variables and fixed effects, respectively. In order to control for information sets that might affect the consumer's choice on vehicle, consumers' past experience variables, and ratings from *Consumers Reports*. With the assumption that consumers' past experience in the use of a certain car affects their utility, two different types of experience variables ($EXP1$, $EXP2$) are used.[13] $EXP1$ is a dummy variable indicating whether or not consumers have previously purchased cars belonging to the same brand. $EXP2$ is a variable that indicates the number of same-branded vehicles in the consumers car ownership history when the household reports owning more than one vehicle.

3.3 Risk Aversion and Signaling

In this section, I explain the empirical strategy that might be able to separate warranty effects caused by two different motives, signaling and risk aversion. In order to separate those two possible reasons, the warranty variable is interacted with two sets of dummy variables, a set of dummy variables that indicates the level of consumers' risk aversion and

[13]Consumers prefer to repeat their purchase decisions and buy from specific firms when they have had positive experiences with a specific firm's products.

a dummy variable that indicates products that has no rating on *Consumer Reports*.

In order to create a set of dummy variables that indicates consumers' level of risk aversion, insurance expenditure for vehicles is used as a proxy that indicates the level of consumers' risk aversion.[14] Using the insurance expenditure variable as a direct measure of the level of consumers' risk aversion brings several problems. First, vehicle insurance expenditure is highly correlated with a consumer's income. Consumers who have higher income more likely to buy expensive cars, so that insurance expenditure will be higher. Second, insurance expenditure is also correlated with the number of cars owned by the consumer. In order to normalize insurance expenditure comparable over all consumers, insurance expenditure is divided by the number of cars owned and then that value is again divided by the consumers' income. This variable indicates the income share of vehicle insurance expenditure per car.

The variable is used to distinguish how consumers are risk averse. However, there might be some regional differences on insurance expenditures. The income share of auto insurance expenditure might be higher in some region not because of householders' risk averseness but because of insurance premium difference based on the region. In order to control the regional difference, 4 different regions are considered, Northeast, Midwest, South, and West.[15] For this matter, the variable, income share of auto insurance expenditure per car, is used to make four different quartile based on each regions. So in this way, the regional differences on insurance expenditure might be considered. For example, a householder who spends 2% of their income on auto insurance and resides in the Northeast region belongs

[14]CES contains detail questions on insurance expenditures by each categories such as vehicle insurance, and other property insurances such as house and life insurance. The vehicle insurance expenditure is used because consumers are more likely to own a car than other properties. So, using other type of insurance will lead a significant loss of observation and the other type of insurance might more dependent on the income rather than consumers risk averseness.

[15]It is possible to consider the insurance premium difference for each states. Indeed, CES data from ICPSR report the state where the householders reside but there are some problems of using the state variable. First, 20 % of sample lack this information. Second, the number of observation for small states are considerably small. For example, CES contains less than 80 householders in Delaware and New Hampshire.

to 3rd quartile, but a householder who spend the same percentage and resides in the South region belongs to the 4th quartile. In this way, the problem of regional insurance premium difference is addressed.[16]

Another interaction term of warranty is used in order to see how a warranty as a signal affects the consumer's choice based on the degree of information that consumers have. When consumers are well aware of product quality(durability), the value of a signal will be relatively low compared to the value of a signal for products that are less known to consumers. With the assumption of decreasing marginal utility of information, the increase in consumer utility from additional information for less known products will be higher than the utility gains of the information for well known products. In other words, the additional information for well known products is relatively less valuable than the additional information on less known products. Thus, the warranty variable is interacted with NO-RATE and the interaction term is used to determine whether or not warranties provide more valuable information for less known products. The interaction term might indicate whether the warranty carries additional information about the product quality(durability). If the warranty carries additional information on the quality of new products (or less known products), then consumers will have a higher preference for longer warranties product for new products or less known products and the coefficient of this interaction term will be positive and significant. When consumers do not consider a warranty as valuable information (or signal of durability), then the coefficient of this variable will not be significant. Therefore, the coefficient of this interaction term will indicate the pure signaling effect of warranty.

3.4 Estimation

The empirical model explained in the previous section is estimated using two different methods, conditional logit and mixed logit. The benefit of conditional logit is that the computational burden is lighter, but the cost of using it is that the conditional logit does

[16]In appendix, CDF of this variable,income share of vehicle insurance expenditure per car, is reported and a table of cutting points for each quartile based on different region is also reported

not consider the heterogeneity of consumers' preference on car characteristics and restricted substitution pattern caused by the IIA assumption. On the other hand, mixed logit directly mitigates the two draw backs of conditional logit, but the computational burden is significantly higher. In order to ease the computational burden, only 6 variables are used as variables that have random parameters. These variables are warranty variable and interaction terms between warranty, other dummy variables that are main focus of this paper, and the variable relating price to income, $(Y_i - P_j)$.

In the mixed logit, the empirical equation(1) can be rewritten as follows,

$$V_{ij} = \alpha' Z_{ij} + \beta' X_{ij} + \gamma_n' W_{ij} \tag{4}$$

where γ_n' is a vector of random parameters that follow the normal distribution. This deterministic part of the utility function with the assumption that unobserved utility base on the extreme value distribution can be written as a probability function,

$$P_{ij} = \int L_{ij}(\cdot) f(\gamma) d\gamma \tag{5}$$

where $f(\gamma)$ is the normal density function with mean $\bar{\gamma}$ and covariance Σ and L_{ij} is the likelihood probability evaluated at parameters ($\theta \in \{\alpha, \beta, \gamma\}$):

$$L_{ij} = \frac{e^{V_{ij}(\theta)}}{\sum_j e^{V_{ij}(\theta)}}. \tag{6}$$

So the probability function will consider consumers' heterogenous preference for the warranty variables and Price - Income variable.

4 Results

The empirical model described in the previous section is estimated using the conditional logit model (Table 1) and mixed logit model (Table 2). The conditional logit results and mixed logit results are quite consistent, although there are several major differences. First, the coefficient of the variable (Income -Price) has a different sign and the coefficient

Table 1: Estimation results : Conditional logit Result

Variable	**Coefficient**	**(Std. Err.)**
length	0.004*	(0.002)
Displacement	0.128*	(0.060)
Consumer Reports rating	-0.002	(0.003)
No rating on *Consumer Reports*	-1.130**	(0.270)
Number of previously owned car for a certain brand	0.608*	(0.245)
Consumer's previous experience of a certain brand	6.280**	(0.427)
Warranty * (budget)	0.065	(0.087)
Warranty * (small)	0.235**	(0.070)
Warranty * (entry-medium)	0.154*	(0.075)
Warranty * (medium)	0.143†	(0.081)
Warranty * (large)	0.098	(0.091)
Warranty * (sporty)	0.181	(0.113)
Warranty * (luxury)	0.132	(0.115)
class (small)	-0.552†	(0.334)
class (entry-medium)	-0.402	(0.354)
class (medium)	-0.398	(0.360)
class (large)	-0.979*	(0.423)
class (sporty)	-1.493**	(0.508)
class (luxury)	-1.953**	(0.555)
Income -price	-0.087	(0.063)
Warranty * Risk aversion (2nd quartile)	0.114	(0.083)
Warranty * Risk aversion (3th quartile)	0.023	(0.088)
Warranty * Risk aversion (4th quartile)	-0.010	(0.096)
Warranty * NORATE	0.043	(0.038)
log likelihood		-3065.2693

†: significant at 10 %

*: significant at 5 %

**: significant at 1 %

Table 2: Estimation results : Mixed logit Result

Variable	**Coefficient**	**(Std. Err.)**
length	0.597**	0.213
Displacement	0.149*	0.064
No rating on *Consumer Reports*	-1.297**	0.274
Number of previously owned car for a certain brand	0.157	0.242
Consumer's previous experience of a certain brand	7.655**	0.547
Consumer Reports rating	-0.001	0.003
Warranty * (budget)	0.005	0.092
Warranty * (small)	0.168*	0.077
Warranty * (entry-medium)	0.070	0.081
Warranty * (medium)	0.067	0.087
Warranty * (large)	-0.099	0.098
Warranty * (sporty)	0.073	1.188
Warranty * (luxury)	0.151	0.123
class (small)	-0.410	0.340
class (entry-medium)	-0.099	0.363
class (medium)	-0.006	0.379
class (large)	-0.338	0.449
class (sporty)	-0.892†	0.536
class (luxury)	-1.801**	0.606
Random Parameters		
Income -price	.024**	.013
Standard Deviation	4.964**	1.081
Warranty * Risk aversion (2nd quartile)	0.210*	0.090
Standard Deviation	0.069	0.103
Warranty * Risk aversion (3th quartile)	0.126	0.096
Standard Deviation	0.016	0.188
Warranty * Risk aversion (4th quartile)	0.068	0.106
Standard Deviation	0.068	0.130
Warranty * NORATE	0.075†	0.039
Standard Deviation	0.027	0.066
log likelihood		-3065.2693

†: significant at 10 %

*: significant at 5 %

**: significant at 1 %

is significant for the mixed logit results. The positive coefficient on the variable is more intuitive than a negative coefficient, since income should have a positive effect on consumers' utility and price should have negative a effect. This result indicates using mixed logit will lead a more intuitive result since the mixed logit model consider consumer heterogeneity with respect to disposable income. Moreover, the standard deviation of the coefficient is also significant and shows that consumers heterogeneity with respect to disposable income exists with statistical significance. So the mixed logit model will lead to better estimates since it considers consumer heterogeneity.

The conditional logit results do not clearly show that more risk averse persons prefer products with longer warranties. However, the mixed logit results show that there exist different preferences for warranty length exist based on consumers risk aversion. Compared to least risk averse group of consumers, the second quartile group prefer longer warranties. Although the third quartile group and fourth quartile group do are not significantly difference. This result might be the problem of proxy variables used to classify consumers' level of risk aversion. The proxy might not be capturing the level of consumers' risk averseion.

The conditional logit results indicate that the effects of a longer warranty is positive but not significant. However, from the Mixed logit results, a longer warranty affects consumers' car choice when they have less information about the products. The coefficient of the signaling variable, an interaction term between the variables NORATE and warranty, is significant for the mixed logit model.

A consumer's past experience with vehicles is an important factor when consumers purchase new vehicles. The coefficients for most of the product characteristics have the expected signs. All those results about the product characteristics are consistent with the results of previous studies. The coefficient of the information variables have the expected signs and three of them are significant. The results clearly show that controlling for the information set is important and the consumer's previous experience has a significant impact on vehicle choice. However, the fact that the *Consumer Report* rating has a negative

effect on consumers' utility is unexpected. This might be caused by the rating scheme of the *Consumer Report*. The rating does not distinguish between types of cars and do not consider car classes. So, luxurious cars tend to have higher scores than normal cars. But the market share of luxurious cars make up a relatively small portion in the car market.

Warranty variables that are interacted with each car class show how a warranty will affect the consumer's choice on buying a new car. All of the warranty effects are positive and three of them are significant. As expected, relatively competitive car classes (small, entry-medium, medium and luxury) have strong positive coefficients in the conditional logit model, although the significance weakened in the mixed logit model. The market share of these car classes is about 85% among the car classes[17]. In the model, each car class is interacted with warranty and car class dummies control for unobserved utility from characteristics in each car class. So the coefficient on the interaction term between car class and warranty might show how warranty affects consumers when they face products within the same car class. The impact of warranty on consumers' indirect utility is relatively significant and positive. This result is also consistent with the variation in the market shares of the firms which changed warranties in recent years. Firms which produce relatively small cars and changed their warranties saw higher market share gains than firms that produce mostly large cars and changed their warranties.

5 Conclusion and further research

In this paper, I tried to show how consumer utility is affected by a warranty as a signal of product quality. The most important finding of this paper is that a longer warranty increases consumers utility and consumers are more likely to buy cars with longer warranties. As expected, I find that consumers' preference for warranty is relatively more pronounced in smaller car classes than in bigger car classes, and I also find weak evidence that different preferences for warranties exist depending on the level of risk aversion.

[17] Automotive News market data book 2002

Although this paper finds evidence that consumers view warranties as a signal of product quality, there are several issues that should be addressed in further researched. Two possible issues are finding a better measuring of risk aversion and evaluating welfare gains from product warranties. Another interesting question might be how competition in the warranty dimension increases the efficiency of the market based on the fact that many firms have changed their warranty in recent years. In order to answer those questions, the magnitude of the effect and elasticity with respect to length of warranty should be correctly calculated. In addition, some counterfactual estimation might help answer these questions.

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APPENDIX

Table 3: Summary statistics

Variable	**Mean**	**Std. Dev.**	
Vehicle Characteristics			
LENGTH	185.775	13.406	
DISPLACEMENT	2.873	0.952	
PRICE	27036.034	14015.904	
WT	4.336	1.877	
classD1	0.065		
classD2	0.14		
classD3	0.103		
classD4	0.168		
classD5	0.15		
classD6	0.093		
classD7	0.28		
Consumers' Characteristics			
INCOME	61287.537	52354.801	
AUTO_INS_perC	0.019	0.058	
1st Quartile Risk aversion	0.211		
2nd Quartile Risk aversion	0.329		
3rd Quartile Risk aversion	0.257		
4th Quartile Risk aversion	0.202		
Variables for Information of Vehicle			
rating	43.468	34.923	125511
norate	0.364	0.481	125511

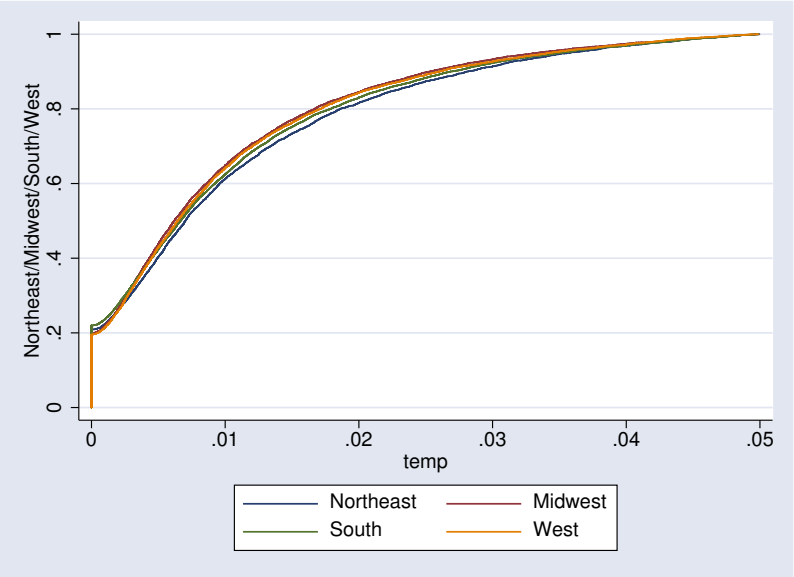

Figure 1: CDF of income share of Auto Insurance expenditure per adult

Table 4: Percentile scores: Cutting points to make variable that indicates level of Consumers' Risk Aversion based on the Region

REGION	Auto 25	Auto 50	Auto 75
Northeast	.0023	.0083	.02132
Midwest	.0020	.0069	.0168
South	.0018	.0076	.0189
West	.0022	.0072	.0173