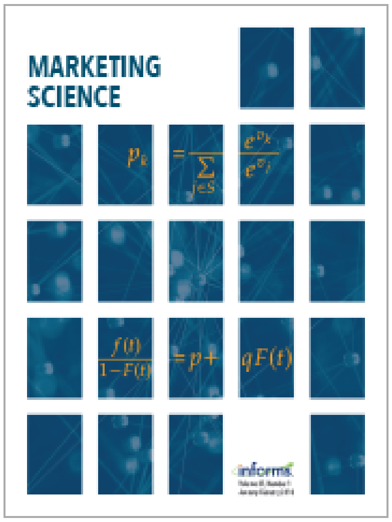

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Risk Preferences and Demand Drivers of Extended Warranties

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We disentangle and study the relative importance of different risk preferences in explaining extended warranty purchases and the high premia paid for them. Empirical and behavioral research on insurance is at odds with whether diminishing returns (curvature of the utility function), or loss aversion and nonlinear probability weighting lead to observed consumer behavior. This lack of consensus is primarily due to the inability of standard choice data to separate different risk preferences, and the consequent need to rely on strong parametric assumptions. We design two conjoint studies (consistent with simultaneous and sequential decision making) with choices about washing machines and extended warranties, where subjects are given failure probabilities and repair costs. Using stated choice data from the surveys, we can nonparametrically identify product and risk preferences. We find that loss aversion is significantly more important than curvature and probability weights in explaining extended warranty choices. Importantly, failure to decompose risk-averse behavior into that arising from curvature, loss aversion, and probability weighting leads to lower washer prices and profits. These findings are robust to alternate reference point assumptions. We rationalize the premia paid for warranties by exploring retailer incentives to price discriminate, and test the theory on complementary goods pricing. Finally, based on counterfactual analysis, forcing separate retailers to sell washers and extended warranties is not necessarily welfare enhancing as cited in the media and previous literature.

Keywords: extended warranties; product insurance; prospect theory; loss aversion; risk aversion; insurance pricing; price discrimination
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1. Introduction

To insure product purchases, consumers routinely pay over 100% markup for extended warranties (protection plans) and service contracts.[1] Understanding why consumers buy extended warranties and what drives them to pay high premia to insure against moderate risks has important implications for pricing and how warranties should be sold. In this paper, we disentangle and study the importance of different risk preferences in driving warranty choices. We use demand estimates to draw managerial implications for product and warranty pricing, shed light on retailers' pricing incentives when selling complementary goods such as products and extended warranties, and explore whether only independent retailers should sell extended warranties.

Unlike manufacturers' base warranties, which are bundled with the product, extended warranties are optional and consumers purchase them depending on their intrinsic preferences and expectations about product quality.[2] Whereas consumers can buy extended warranties for a product purchased in the past, most extended warranties are purchased at the time of product purchase and thus we focus on such extended warranties.[3] As per the trade publication Warranty Week, extended warranties worth $15 billion were sold in 2004 and the industry is growing at 7% per year, thus pointing to the importance and relevance of this industry.

In Table 1, we report data on insurance prices and claims from previous research and a large midwestern home appliance retailer. Firms typically enjoy a contribution margin upward of 40% (67% markup) for home and auto insurance. Compared to an average contribution margin of 15% on home appliances

[1] Henceforth, we will be using the terms "warranties" and "service contracts" interchangeably. If not mentioned otherwise, warranties refer to extended warranties. Any reference to base or manufacturer warranties will be explicit.

[2] Unlike base warranties, extended warranties are additional stock keeping units (SKUs) that consumers can buy with products. Extended warranty contracts are underwritten and serviced either by the retailer or third-party insurers. For example, extended warranties sold at Best Buy are serviced by Geek Squad, whereas those sold at Circuit City are serviced by Bankers Warranty Group (BWG). The Home Depot and Lowe's have their own repair specialists.

[3] Warranty Week (2007), "Extended warranty solution," July 25, 2007.

Table 1 Contribution Margins in Insurance

Context	Data source	Insurance price[a]	Actuarially fair price[b]	Contribution margin %
		Regular vs. High deductible and premium choice		
Home	Sydnor (2010)	$100	$21	79
Comprehensive auto	Barseghyan et al. (2013)	$23	$10.50	54
Home	Barseghyan et al. (2013)	$74	$44.50	40
Auto	Cohen and Einav (2007)	NIS 399	NIS 208	48
		Product insurance		
Extended warranties	Midwestern retailer	$118[c]	$53[d]	55

Notes. The table presents data on deductibles and premiums from different papers on home and auto insurance. Additionally, the table includes the average warranty prices and expected repair costs from a large midwestern retailer. The average is calculated across different categories of home appliances including refrigerators, microwave ovens, washers, dryers, electric and gas grills, and so on.

[a]For home and auto insurance, insurance price is calculated as the increase in premium required to reduce the deductible from the most frequently bought level to one lower level.

[b]Actuarially fair price for home and auto insurance is calculated based on the claims made by the consumers. Specifically, this price is the ex post probability of making a claim multiplied by the deduction in the deductible amount.

[c]The insurance price for extended warranties is the average price of a three-year warranty across 13 different product categories.

[d]The actuarially fair price for extended warranties is the average cost of making claims for all of the claims across 13 different product categories as observed in the data.

and electronics, contribution margins on warranties (as cited in the popular press) are approximately 50%–60% (100%–150% markup), which is consistent with Table 1.[4] Researchers argue that these margins are driven by consumers' aversion to risk, which is operationalized by a concave utility function. Using data from the home appliance retailer, we calibrate the degree of concavity required to rationalize warranty choices.[5] We find that consumer choices imply risk-aversion coefficients such that they will reject a gamble that has an equal chance of winning $100 and losing $5 or less. Thus, consistent with Rabin and Thaler (2001) and Sydnor (2010), an extreme degree of risk aversion (curvature) is required to rationalize warranty choices and the premia paid for them.

We consider three different dimensions leading to risk-averse behavior: risk aversion, which is equivalent to diminishing returns in utility; loss aversion, in which losses loom larger than gains of similar magnitude; and nonlinear weighting (also known as decision weighting) of failure probabilities (Kahneman and Tversky 1979).[6,7] Consistent with Köbberling and Wakker (2005), we view risk attitude as stemming from three different components: risk aversion (curvature of utility function), loss aversion, and decision weighting. All three components should be taken into account simultaneously to assess the risk attitude (risk averse or risk seeking) and predict individual behavior. We disentangle these risk preferences and study their relative importance in explaining warranty choices and their impact on product and warranty pricing.[8] Separating these risk preferences requires within-consumer variation in failure probabilities and other product characteristics. To the extent that we do not observe failure probabilities in field data, any inference hinges on parametric assumptions and assumptions about rational expectations (see, e.g., Cohen and Einav 2007 and Chen et al. 2009).[9] Estimates of probability weights are thus contingent on these assumptions and may lead to biased estimates of curvature of the utility function (Abdellaoui et al. 2008).[10] We design conjoint surveys in which we give beliefs to subjects, consequently facilitating nonparametric identification of risk preferences that we could otherwise not achieve in panel data. Using stated preference data as opposed to scanner data, however, poses a trade-off between the purchase setting and the ability to recover unbiased estimates.

[4] http://www.bbb.org/us/article/know-the-deal-on-extended-warranties-and-service-contracts-2443 and http://www.cbsnews.com/stories/2007/08/10/earlyshow/contributors/raymartin/main3156565.shtml.

[5] Details of the calibration exercise are present in the online appendix (available as supplemental material at http://dx.doi.org/10.1287/mksc.2014.0879).

[6] Henceforth, we will refer to risk attitude stemming from a concave utility function as risk aversion and that stemming from greater sensitivity to losses as loss aversion. We make this distinction only to make discussion of results easier.

[7] Wakker et al. (1997) rationalize warranty purchases through loss aversion and nonlinear weights consumers assign to failure probabilities.

[8] Bryant and Gerner (1982), Huysentruyt and Read (2010), and Chu and Chintagunta (2009) estimate demand for warranties assuming a concave utility function. By contrast, Padmanabhan and Rao (1993), Padmanabhan (1995), and Soberman (2003) study partial warranty coverage and reasons for the existence of warranties but do not estimate demand for warranties.

[9] In §2.2, we shed more light on the identification issues related to panel data.

[10] Barseghyan et al. (2013) use data on deductible choices in auto and home insurance and rely on parametric assumptions to estimate risk preferences. Contrary to our finding, they conclude that nonlinear probability weighting drives insurance choices.

We study consumer decisions related to extended warranties in the context of purchasing a washing machine (washer). As per Consumer Reports, washing machines typically have a 25%–29% failure rate in the first four years of service, and the attachment rate of warranties is upward of 20%.[11] Further, unlike electronic goods, retailers do not engage in intertemporal price discrimination for washing machines, and the decision of not buying does not hinge on expectations about future product characteristics. Together, these features make washers a relevant and appealing context. Whereas firms such as Best Buy stress warranty characteristics only after product purchase (and try to sell warranties once the consumer makes the product purchase decision), others such as Abt Electronics simultaneously provide product and warranty information as a joint decision. The former implies a sequential decision-making process, whereas the latter implies a simultaneous process. In the absence of any theoretical guidance on whether warranty purchase is a simultaneous or sequential process, we design two conjoint studies—one with the simultaneous choice of washer and warranty and a second one with warranty choice conditional on washer choice. We estimate and compare preferences from these studies to (1) understand what drives extended warranty choices, (2) explore the high premia paid, and (3) study the impact of the decision-making process on preferences and pricing.

Reduced-form analysis of the raw data provides overwhelming evidence in support of loss aversion and reference dependence. We obtain four key results. First, on average, subjects have a slightly concave value function and are roughly three to four times more sensitive to losses than to gains, which, although on the higher side, is consistent with the vast behavioral literature in which the loss-aversion parameter is estimated around 2.25. We find evidence in support of probability weighting, and consistent with the literature, find on average an inverse *S*-shaped weighting function. Considerable heterogeneity exists in all risk preferences. Second, based on the out-of-sample predictions, and after accounting for product and price preferences, loss aversion explains warranty choices substantially better than curvature and weights assigned to failure probabilities. These findings are robust to alternate functional-form assumptions.

Third, failure to separate different risk preferences leads to biased estimates of price sensitivity and willingness to pay, which has important managerial implications for product and warranty pricing and translates to around 38% (23%) lower profits under the simultaneous (sequential) model.[12] Finally, based on the sequential survey, we find that retailers have an incentive to price discriminate by charging high markups for extended warranties as observed in practice. This finding has implications for how extended warranties should be sold. Forcing separate retailers to sell washers and warranties leads to a 7% increase in the washer price and a 3% decrease in the warranty price. Together, these price changes make the consumers worse off, and they need to be given an average of $36 (3.34% of washer price) to make them indifferent to the policy change.

This research contributes to the marketing and behavioral economics literature in several ways. First, we make a methodological contribution through the survey design that allows us to nonparametrically (and jointly) estimate risk and product preferences.[13] Second, we quantify the relative importance of different risk preferences in explaining warranty choices and highlight the managerial implications for pricing. The extant literature finds incidence of different risk preferences but does not elaborate on their relative importance in making choices. Third, we test the retailers' incentives to price discriminate (Oi 1971, Rosen and Rosenfield 1997) and understand the role of preferences in how extended warranties should be sold.[14] We explore whether warranties should be sold independently, and whether high premiums for warranties are driven solely by retailers acting as monopolists, as posited by Kunreuther and Pauly (2006). To the best of our knowledge, no prior research empirically explores the complementary goods nature of products and warranties and its impact on pricing and policy.

This research draws from several different streams of literature. First and foremost, we study the role of reference dependence and "prospect theoretic" preferences (Kahneman and Tversky 1979, Tversky and Kahneman 1992) in extended warranty choices. Our research is similar in spirit to Schoemaker and Kunreuther (1979) who show that insurance choices involving monetary gambles are more consistent with prospect theory (than with expected utility theory). Consistent with Ho et al. (2006), we estimate consumers' intrinsic preference for warranty (peace of

[11] Attachment rate is the percentage of all product purchases for which a warranty is also purchased.

[12] We also find that relieving consumers of their behavioral bias reduces risk-averse behavior and leads to high profits.

[13] Unlike previous research (Abdellaoui 2000, Abdellaoui et al. 2007, Gonzalez and Wu 1999), our approach is not entirely nonparametric, because we make assumptions about the utility shocks. This assumption, though, is rather innocuous given the identification results hold for any generally acceptable distribution of shocks, and that we allow for heterogeneous preferences.

[14] Gil and Hartmann (2009) provide an empirical test for price discrimination in the context of concession goods at movie theaters.

mind), which may be viewed as an inflation in product value through warranty purchase (endowment effect). Second, we extend the marketing literature on reference prices (Winer 1986, Hardie et al. 1993, Bell and Lattin 2000, Erdem et al. 2001, Bronnenberg and Wathieu 1996) to risky choices, while allowing consumers to be more sensitive to warranty prices as compared to product prices (asymmetric response).[15]

The rest of the paper is organized as follows. In §2, we outline the model and identification strategy. In §3, we present survey design, data description, and reduced-form results. Sections 4 and 5 report estimation details and results. We discuss the pricing implications in §6 and conclude in §7.

2. Methodology Overview

Consumers' decision to purchase extended warranties could either be simultaneous (joint with product purchase) or sequential (conditional on product purchase).[16] One objective of this paper is to estimate and compare preferences across different decision-making processes. Thus, we first present a simultaneous model of consumers' purchase decisions for durable goods with an associated failure probability. We then offer a brief discussion on the limitations of panel data and how preferences can be nonparametrically identified from survey data. Finally, we outline the sequential model of decision making.

Although we apply our model in the context of washing machines, the model is extremely general and can be easily extended to other durable goods and insurance. Consistent with prospect theory, we first define a value function for any utility index y (utility a risk-neutral subject would get) and reference point r as $v(y, r)$ such that[17]

$$v(y, r) = \begin{cases} v_g(y - r) + z(r); & y \geq r \\ v_l(y - r) + z(r); & y < r, \end{cases} \tag{1}$$

where $v_g(\cdot)$ and $v_l(\cdot)$ are the value functions in gains and losses, respectively, and $(z(r))$ is the value from consumption of r. Utility from the reference point $(z(r))$ is common to all alternatives and is irrelevant to decision making. We define gains and losses over utility index, and consistent with the reference price literature, allow warranty price to be treated as a loss as compared to product price.

2.1. Simultaneous Choice Model

Consumers simultaneously choose between J $(=2$ in our application) different washing machines, with or without warranty, and the outside option of no purchase. Let $x_j = (p_j, \omega_j, c_j, X_j)$ be a vector including the product price p_j, warranty price ω_j, repair cost c_j, and a vector of product attributes X_j for washer j, respectively. We define $y(x_j \mid \theta_i)$ as the linear utility index corresponding to the deterministic utility a consumer i gets from buying brand j or paying a repair cost; θ_i are the consumer-specific preference parameters.

Washing machines fail for a variety of reasons related to motor, valves, pump, timer, and so on. Accounting for the risk from failure, and utilizing Equation (1), the value consumer i gets from buying brand j with no warranty (nw) is given by

$$\begin{aligned} u_{ij}^{nw} = {} & \delta_i(\pi_j) v(y_{ij}^{nw}, r \mid \textit{failure}) \\ & + (1 - \delta_i(\pi_j)) v(y_{ij}^{nw}, r \mid \textit{no failure}) + \epsilon_{ij}^{nw}, \end{aligned} \tag{2}$$

where $\delta_i(\pi_j)$ is the weight consumer i assigns to failure probability π_j for brand j,[18] and ϵ_{ij}^{nw} are the random utility shocks unobserved to the researcher.

We assume the reference point of a consumer before making any decision is the utility from no purchase (status quo).[19] Thus, the value consumers get from no purchase is $v(0)$, which is normalized to 0, that is, $v(0) = 0$. Once the consumer decides to purchase the product, the reference point shifts to the utility a consumer gets from a working product; which, implicitly implies consumers segregate gains and losses from product (and warranty) purchase and repair costs, and have different mental accounts for them (Thaler 1985). Hence, although product price is not considered a loss (Novemsky and Kahneman 2005), the repair cost is perceived as a loss relative to the utility from consumption.[20]

[15] Gächter et al. (2010) use monetary gambles to compare loss aversion in risk-less and risky choices.

[16] If we believe consumers decide between buying a better product without a warranty and a lower-quality product with a warranty, this decision is a simultaneous one. On the contrary, if product choice is independent of whether to buy a warranty or not, the warranty purchase decision is sequential.

[17] Kahneman and Tversky (1979) use the phrase "value function" (as opposed to utility function) to highlight the fact that the argument is a gain (loss) measured with respect to a reference point. The utility function commonly referred to when using expected utility theory has the final consumption state as its argument (as opposed to gains or losses).

[18] Under prospect theory, probability weights could be different in the gains and losses domain. The model outlined here assumes the same probability weighting function in both gains and losses. This assumption is not critical to model identification; rather, it is made for ease of estimation. Model outline and discussion on identification with separate probability weights can be requested from the author.

[19] Whereas Kőszegi and Rabin (2006) outline a theory for endogenous reference-point formation, recent empirical work (von Gaudecker et al. 2011, Bruhin et al. 2010) assumes an exogenous reference point. We maintain this assumption in current research, and do robustness checks in the online appendix.

[20] The value function implies consumers have different mental accounts for (and segregate, as opposed to integrate) utility from

Conditional on the product failing, the value consumer i gets from purchasing brand j without warranty can now be written as $v(y_{ij}^{nw}, r \mid failure) = v(y_{ij}^{nw}) + v_l(y_{ij}^c)$, where $v_l(y_{ij}^c)$ represents the negative value (considered a loss) a consumer gets from paying repair costs and is measured with respect to the utility from a working product. The utility index subsumes the reference point, and product preferences are measured relative to this reference point. Further, given that the reference point is common to all alternatives, the value from the reference point is rescaled to 0. Similarly, the value consumer i gets from purchasing brand j without warranty (conditional on no failure) is given by $v(y_{ij}^{nw}, r \mid no\ failure) = v(y_{ij}^{nw})$. Combining these equations, Equation (2) can be rewritten as

$$u_{ij}^{nw} = v(y_{ij}^{nw}) + \delta_i(\pi_j) v_l(y_{ij}^c) + \epsilon_{ij}^{nw} = v_{i,nw}^*(x_j) + \epsilon_{ij}^{nw}. \quad (3)$$

Assume consumers do not incur any repair costs if the product fails under warranty, and that the retailer provides the same quality of service irrespective of whether the consumer bought a warranty. Given the reference-point assumption, the value consumer i gets from buying brand j with warranty (w) is given by

$$u_{ij}^{w} = v(y_{ij}^{w}) + \epsilon_{ij}^{w} = v_{i,w}^*(x_j) + \epsilon_{ij}^{w}, \quad (4)$$

and is independent of the failure probability and repair costs. Finally, the value consumer i gets from no purchase is given by $u_{i,0} = \epsilon_{i,0}$. To avoid the no-purchase decision being contingent on the vector of current state variables (e.g., beliefs about future product characteristics or product characteristics at other stores), the outside option is restricted to using the current method of doing laundry (laundromat or using the current washer, etc.).

A consumer adopts brand j (with or without warranty) if and only if $v_{i,k}^*(x_j) + \epsilon_{ij}^k \geq v_{i,k'}^*(x_{j'}) + \epsilon_{ij'}^{k'}$ for all $j, j' \in J$, and $k, k' \in \{w, nw\}$, where $j \neq j'$ and/or $k \neq k'$. We assume the random utility shocks are type I extreme value distributed. For each consumer i, we observe the adoption choice d_{ij}^k where $d_{ij}^k = 1$ if consumer i chooses brand j with $k \in \{w, nw\}$ and $d_{ij}^k = 0$ otherwise. The conditional choice probability (CCP) that consumer i chooses brand j with (without) warranty is then given by a multinomial logit model of the form

$$\Pr\{d_{ij}^k = 1\} = \frac{\exp(v_{i,k}^*(x_j))}{1 + \sum_{j' \in J} \sum_{k' \in \{w,nw\}} \exp(v_{i,k'}^*(x_{j'}))}. \quad (5)$$

product purchase and repair costs. This is intuitive given repair costs are (potentially) incurred in the future, and is consistent with the silver-lining effect in Jarnebrant et al. (2009) and with Ho and Zhang (2008). We report estimates from robustness checks around the assumption of reference point and mental accounting in the online appendix. Consistent with Tversky and Kahneman (1991), we do find some differences in the estimates of loss aversion and price sensitivity, but overall, the qualitative findings and out-of-sample predictions stay the same.

2.2. Identification of Risk Preferences

Previous approaches that nonparametrically identify risk preferences (Abdellaoui 2000, Abdellaoui et al. 2007, Gonzalez and Wu 1999, Booij and van de Kuilen 2009) rely on prior knowledge of whether an outcome is a gain or a loss, and work only when utility is defined over a single characteristic (e.g., money). By contrast, utility from consumption is a multidimensional construct that depends on unobserved individual-specific preferences. Further, a prospect cannot a priori be classified as a gain or a loss, making a direct application of such approaches to consumption contexts difficult. This paper differs from previous work in that it extends the literature on nonparametric identification to settings in which utility is defined over multiple characteristics and a prospect cannot be preclassified as a gain or a loss.

Note that the model outlined above assumes that failure probabilities are known to consumers and observed by researchers. As we outline below, knowledge of and within-consumer variation in failure probabilities is critical to get unbiased estimates of risk preferences. Abdellaoui et al. (2008) show that if consumers substantially overweight smaller probabilities, risk-averse behavior and convex value function can coexist. Put differently, estimating the individual-level weighting function is key to providing unbiased estimates of the curvature of the value function. Scanner data on purchases of big-ticket items are typically cross-sectional and include one observation per consumer, thus making estimation of individual-level preferences impossible. Even if researchers have access to panel data, failure probabilities are unobserved and researchers rely on the assumption of rational expectations.[21] Thus, using scanner data (panel or cross-sectional) requires one to make strong assumptions about the failure probabilities and weighting function, which may bias value function curvature estimates. Stated preference data are better suited to this problem because of the researchers' ability to control and manipulate failure probabilities (and other characteristics) within subjects.[22]

We now outline a proof for nonparametric identification of risk preferences that exploits within-consumer (subject) variation in washer and warranty characteristics. We discuss identification for the simultaneous decision-making process outlined in §2.1.

[21] See, for example, Cohen and Einav (2007) in the context of auto insurance.

[22] An alternate approach would be to elicit consumers' beliefs about failure probabilities and repair costs, and combine them with panel data on purchases to study decision making. We leave this avenue for future research.

2.2.1. Utility index. Suppressing the individual and brand subscripts, we first define the utility index from product purchase and payment for repairs as

$$y^w = h(X_w) - p - \lambda\omega, \tag{6}$$

$$y^{nw} = h(X_{nw}) - p, \tag{7}$$

$$y^c = -\lambda c, \tag{8}$$

where $h(X_k)$; $k \in \{w, nw\}$ is some arbitrary function of product characteristics (X) and intrinsic preferences; λ measures the asymmetric response to product and warranty prices. We allow warranty price to be considered a loss relative to the product price, which is based on our reduced-form findings (reported in §3.3) and is consistent with the literature.[23] We allow subjects to have different preferences for the product with (without) warranty. Allowing for mental accounting makes the choice-specific value additively separable in brand preference and probability weighting function, which facilitates separate estimation of brand preference and intrinsic preference for warranties. For the discussion on identification, we normalize the price coefficient in the utility index to 1, and ignore the k subscript and consider one function $h(X)$.[24] In §4, we generalize the expression for utility index.

The model primitives we need to identify include (components of) utility index y, value function $v(y)$, and probability weighting function $\delta(\pi)$. Assuming we have access to an arbitrarily large data set generated from consumer choices, we can observe the conditional choice probabilities associated with different alternatives. Given these CCPs and the type 1 extreme value distribution assumption, the choice-specific value differences ($\phi_k^{-1}(x)$) can be inferred by a simple inversion of choice probabilities as follows:[25, 26]

$$\phi_w^{-1}(x) = v_w^*(x) - v(0) \tag{9}$$

$$= \log(\Pr\{d_w = 1\}) - \log(\Pr\{d_0 = 1\}). \tag{10}$$

Let $\mathbb{X}$ be the support of x. Assume the support $\mathbb{X}$ is large enough such that for any X', an $x' \in \mathbb{X}$ exists such that (i) X' is the X-component of x' and (ii) $v_w^*(x') = v(h(X') - p' - \lambda\omega') = 0$. Thus, for any product and warranty price and characteristics X', we can find a corresponding $h(X')$ and λ such that $h(X') - p' - \lambda\omega' = 0$. The entire function $h(X)$ (and λ) is nonparametrically identified by varying product characteristics and product or warranty prices. If $h(X) \geq 0$, that is, if the product is weakly desirable when price equals zero (apart from idiosyncratic reasons captured by the latent utility term), the assumption on the support of $\mathbb{X}$ can be achieved by varying the price p sufficiently for any X value. Note that the loss-aversion parameter is nonparametrically identified from the value function asymmetry as we detail below. Varying sensitivity to product and warranty prices aids identification of loss aversion.

2.2.2. Risk aversion (curvature) and loss aversion. To identify $v(y)$ on a suitable range, say $[y_L, y_U]$, where $y_L < 0$ and $y_U > 0$, we now only need a sufficiently large support $\mathbb{X}$ such that for any $y \in [y_L, y_U]$, an x exists such that $y = h(X) - p - \lambda\omega$ and hence $v(y) = v_w^*(x)$. The value function in gains and losses is identified as long as the utility index contains some positively valued attribute allowing it to take values in both gains and losses domains. The identification argument is exactly the same as that for utility functions in nonlinear discrete choice models.

Under expected utility theory, risk aversion is a measure of the curvature of the value (utility) function. Conditional on nonparametrically estimating the value function in gains and losses, we can get an estimate of value function curvature in gains and losses separately, which provides a measure of risk aversion. The literature has defined loss aversion based on the ratio of value function, rate of change of value function, and so on, at different points (see Köbberling and Wakker 2005 for more details). Yet, if we know the shape of the value function in gains and losses, we can estimate loss aversion subject to any definition. Broadly speaking, the identification of loss aversion rests on the asymmetry in the value function in gains and losses, and response to product and warranty prices.

2.2.3. Probability weighting function. As before, assume the support $\mathbb{X}$ is large enough such that for any c'', an $x'' \in \mathbb{X}$ exists such that c'' is the c-component of x''. The choice-specific value difference between buying the product without warranty (nw) and the outside option of no purchase at x is given by $\phi_{nw}^{-1}(x) = v_{nw}^*(x) - v(0)$. Utilizing this and Equation (3), and taking the difference of choice-specific value differences at x and x'', we get

$$\delta(\pi) = \frac{\phi_{nw}^{-1}(x) - \phi_{nw}^{-1}(x'')}{v(y^c) - v(y^{c''})}. \tag{11}$$

Equation (11) implies that the probability weight associated with a particular failure probability is identified by varying repair costs (holding other characteristics fixed). The probability weighting function then

[23] See, for example, Tversky and Kahneman (1991), Ho et al. (2006), and Bronnenberg and Wathieu (1996).

[24] The identification results holds if, instead, we impose a normalization on the value function.

[25] Hotz and Miller (1993) show that a similar inversion exists for more general distributions of the error terms, but they may not have a convenient closed form. Refer to Dubé et al. (2014) for more details on the inversion of CCPs.

[26] In a survey, the error terms can be interpreted as stochastic noise induced because of subjects' carelessness or inattentiveness.

is identified through within-subject variation in failure probabilities.

2.3. Sequential Choice Model

We now outline the sequential choice model in the context of a conjoint survey. The sequential choice model differs from the simultaneous model in that decision making is a two-stage process. In the first stage, subjects make a washer choice and, conditional on purchase, in the second stage, they make a decision with respect to the warranty. The value subjects get from purchasing brand j washer in the first stage is given by $u_{ij} = v(y_{ij}) + \epsilon_{ij}$. Assuming ϵ_{ij} follow a type 1 extreme value distribution, the unconditional probability of choosing brand j in the first stage is given by

$$\Pr\{d_{ij} = 1\} = \frac{\exp(v(y_{ij}))}{1 + \sum_{j' \in J} \exp(v(y_{ij'}))}. \tag{12}$$

In the second stage, subjects learn about failure probability, repair cost, and warranty price and make a warranty purchase decision. Additionally, subjects are allowed to not purchase the washer altogether. The value subjects get from buying the washer with a warranty can be written as

$$u_{ij}^{w} = v(y_{ij}) + v(y_{ij}^{w}) + \epsilon_{ij}^{w} \tag{13}$$

$$= v_{i,w}^{*}(x_j) + \epsilon_{ij}^{w}, \tag{14}$$

where y_{ij}^{w} is the utility index from buying a warranty and $v(y_{ij})$ is the deterministic portion of the value from washer purchase in the first stage. If the subject decides not to purchase the warranty, the value from buying only the product is given by

$$u_{ij}^{nw} = v(y_{ij}) + \delta_i(\pi_j) v_l(y_{ij}^{c}) + \epsilon_{ij}^{nw} \tag{15}$$

$$= v_{i,nw}^{*}(x_j) + \epsilon_{ij}^{nw}. \tag{16}$$

Recall that in the second stage, subjects can also choose to not buy the washer.[27] The value from choosing the outside option is given by $u_{ij}^{0} = \epsilon_{ij}^{0}$. Assuming ϵ_{ij}^{k} follow a type 1 extreme value distribution, the probability of warranty purchase conditional on product purchase (in the first stage) is given by[28]

$$\Pr\{d_{ij}^{w} = 1 \mid d_{ij} = 1\} = \frac{\exp(v_{i,w}^{*}(x_j))}{1 + \sum_{k \in \{w, nw\}} \exp(v_{i,k}^{*}(x_j))}. \tag{17}$$

Using Bayes' rule, the unconditional probability of purchasing a washer with a warranty is given by $\Pr\{d_{ij}^{w} = 1\} = \Pr\{d_{ij}^{w} = 1 \mid d_{ij} = 1\} \Pr\{d_{ij} = 1\}$.[29] Compared to the simultaneous model, in the sequential model, washer choice is independent of warranty price and repair costs of all competing brands, and the decision to purchase a warranty is independent of the competing brands' characteristics.

Extending the identification proof to the sequential decision-making process is straightforward. Intuitively, the value function (utility index, risk and loss aversion) is identified from the first-stage choices concerning washing machines, where failure probability does not influence choice-specific values. Conditional on the identification of value function, we identify the probability weighting function and warranty preference from within-subject variation in failure probabilities, repair costs, and warranty choices in the second stage.[30]

3. Survey and Data

3.1. Survey Design.

As we point out earlier, there is no theoretical guidance on whether washer and warranty purchase is a simultaneous or sequential decision. Further, in practice, we find support for both simultaneous and sequential decision making. Thus, we design two online conjoint surveys differing in the simultaneity of washer and warranty choice. Whereas the first survey is consistent with a simultaneous decision-making process wherein subjects simultaneously make purchase decisions for a washer and a warranty, the second survey is consistent with sequential decision making and subjects make a purchase decision for a warranty only once they've chosen to purchase the washer. In both surveys, several introductory screens provide subjects an overview of the washing machines and possible benefits of buying an extended warranty. Subjects are informed that the retailer repairs washers and that the quality of service provided is independent of warranty purchase.

[27] The option to not purchase the washer in the second stage is purely to make the choice task realistic. In discussions with different retailers, we learned salespeople focus on failure rate and repair costs only after consumers choose a washer. Thus, the no-purchase option in the second stage allows consumers to not purchase the washer after learning about failure characteristics.

[28] We allow preference parameters from the first and second stages to be correlated to account for the possible correlation between utility from product adoption and warranty purchase.

[29] The specification for the sequential model assumes subjects do not account for warranty choice (second-stage decision) while making the washer choice (first-stage decision). An alternate specification (reported in the online appendix) allowing for second-stage utility to influence choice in the first stage yields qualitatively similar results.

[30] The choice models do not account for the fact that washer and warranty costs are incurred in the current period, whereas repair costs are (possibly) incurred in the future and should be discounted accordingly. Put differently, we implicitly assume consumers do not discount the future and consequently, estimate a lower bound on loss aversion. If subjects have a linear value function and their beliefs about when the washer fails do not vary across choice tasks, we underpredict loss aversion by up to 10%–15% for a homogeneous annual discount factor of 0.95.

Further, the repair costs and failure probabilities are provided to the subjects and are manipulated across choice tasks. Providing subjects this information is important to rule out arguments in favor of convenience or search costs related to finding a repair shop, and uncertainty associated with failure characteristics and quality of service, which could lead to background risk and provide biased estimates of risk preferences (Harrison et al. 2007).[31] The online appendix presents the screen providing subjects information about product characteristics they see in each choice task.

In the simultaneous survey, subjects choose between two competing washing machines (with or without warranty) and not buying the product. The online appendix presents a standard choice task in the simultaneous survey. To make the product choices realistic, in addition to the washer brand, we include the loading type (front versus top) as a washer characteristic.[32] On each screen, subjects have the option of seeing other characteristics common to both washers and characteristics of the warranty being offered. Each subject completes a total of three blocks that are randomly assigned to subjects. Across choice tasks, we vary all of the product characteristics shown to subjects. We vary the failure probability between 5% and 80% to facilitate estimation of probability weights.[33]

In the sequential survey, subjects first choose between alternate brands of washers. If the subjects choose to purchase a washer, we provide information about failure probability, warranty price, and repair costs specific to the chosen washer. The subjects then make a warranty choice and are allowed to not purchase the washer (after learning about the failure characteristics) as well.[34] First- and second-stage choice tasks from the sequential choice survey are available in the online appendix. Each subject completes two blocks of questions.

3.2. Data Description.

We collected the data using the online panel of Global Market Insight, Inc., a national market research company. The panel is representative of the U.S. population. Three hundred twenty-six (236) respondents completed the simultaneous (sequential) surveys, resulting in a total of 7,248 (4,719) choices.[35] The distribution of demographics in the sample is reported in the online appendix. Table 2 summarizes purchasing habits and familiarity with washers and warranties across subjects. In both studies, the majority of subjects were familiar with extended warranties before they took the survey and over three-quarters had purchased warranties for either home appliances or electronics goods. Around 70% of the subjects had purchased a washer in the past and over 80% use a washer at least once a week or more. All subjects found the survey questions to be clear and over 70% of the subjects believed the prices and characteristics shown were realistic. Thus, subjects sampled are not only representative of the population, but are also relevant for this research.

In Table 3, we present the distribution of modal choices, the number of times modal choice is chosen, and the number of distinct choices within each block of questions. We find that subjects choose all of the choices with product purchase with a warranty being the more favored choice across both surveys. In the sequential survey, we observe a small fraction of subjects for whom the modal choice is not to purchase the washer after learning about the failure characteristics.[36] Within each block, the majority of subjects chose the modal choice between three to six times, suggesting substantial variation in choices. The same pattern is present in the number of distinct choices chosen within each block, where the majority of the subjects chose more than two distinct choices. This within-subject variation is crucial to estimating heterogeneous product and risk preferences. Finally, Figure 1, based on the simultaneous survey, shows that the warranty attachment rate initially increases with increasing failure probability but is relatively constant for failure probabilities in excess of 35%.

[31] In the survey, we provide subjects detailed information on product characteristics and how each characteristic relates to performance. We inform them that the washers differ only on these characteristics and perform identically with respect to all other characteristics.

[32] One possible critique of the surveys is that we make subjects focus on characteristics that might not otherwise be important in their decision making. For example, consumers may not explicitly think of repair costs or may not account for probabilities in terms of numbers. Williamson et al. (2000) and Huysentruyt and Read (2010) show that consumers think about washer prices and repair costs and know how to account for failure probabilities. Thus, evidence in the literature suggests that the characteristics shown to subjects in the surveys are important and that consumers consider them in their warranty purchase decisions.

[33] We over-weigh probabilities in the range of true failure rates as per Consumer Reports. Larger probabilities are used to make sure that estimates of weighting function are not driven by parametric assumptions.

[34] As with monetary gambles, risk preferences in the context of product and warranties can also be elicited from a completely different survey design in which, instead of choices, subjects provide willingness to pay for a warranty. In the online appendix, we report risk preferences from such an experiment, which are similar to those found in the base model.

[35] We ensured that no overlap occurred in the subjects sampled across the two experiments.

[36] These choice patterns provide some validity to the assumption that subjects do not account for failure characteristics while making washer purchase decisions in the first stage.

Table 2 Survey Summary—Familiarity and Purchase Behavior for Washers and Warranties

	Simultaneous survey		Sequential survey	
	N	Percent	*N*	Percent
Warranty familiarity				
Not at all familiar (1)	21	6	8	3
Somewhat familiar (2)	81	25	73	31
Familiar (3)	110	34	81	34
Very familiar (4)	73	22	41	17
Extremely familiar (5)	41	13	33	14
Warranty purchase				
Yes, home appliances only	61	19	49	21
Yes, electronics only	61	19	36	15
Yes, for both home appliances and electronics	133	41	94	40
Never	71	22	57	24
Washer purchase				
Yes, I have purchased a new washing machine before	222	68	174	74
Yes, I have considered but never purchased a new washing machine before	61	19	34	14
No, I have never purchased a new washing machine	43	13	28	12
Washing machine usage				
Once a week or more	263	81	200	85
Once in two weeks	40	12	22	9
Once in three weeks	10	3	9	4
Once a month or less	13	4	5	2
Questions clear?				
Yes	324	99	236	100
No (please elaborate)	2	1	0	0
Prices and costs realistic?				
Yes, the prices and repair costs were realistic	237	73	170	72
The washer and warranty prices were realistic but repair costs were not believable	74	23	49	21
No, the prices and repair costs were not realistic	15	5	17	7

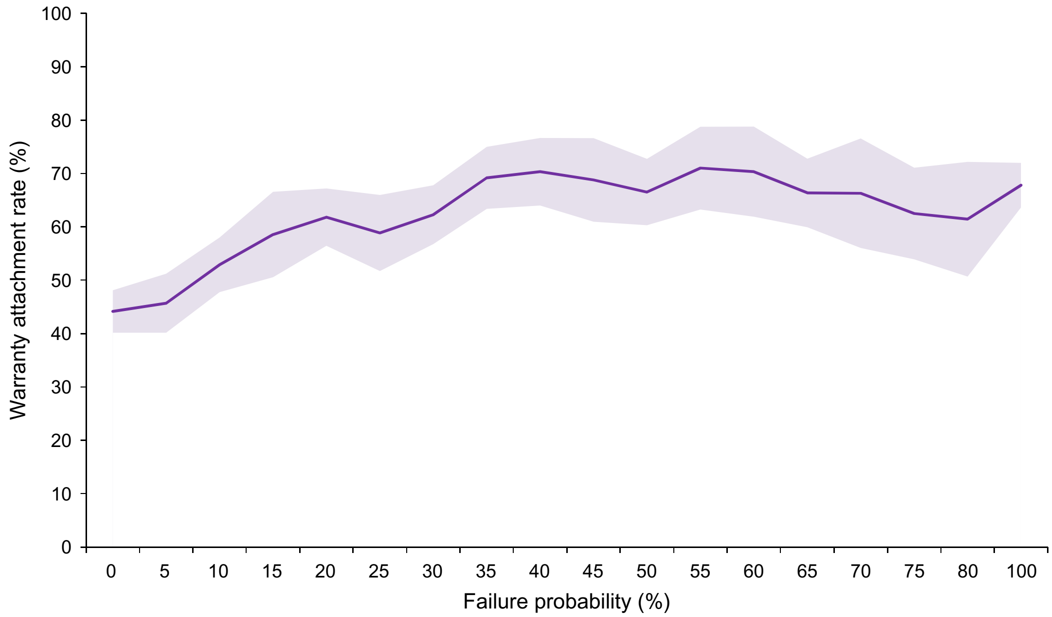
Note. The table summarizes the subjects' familiarity with warranties and their usage and purchase behavior for washing machines, for both the simultaneous and sequential choice surveys.

Table 3 Survey Summary—Distribution of Choices

	Simultaneous survey		Sequential survey	
	No. of blocks	Percent	No. of blocks	Percent
Modal choice distribution				
Product 1—No warranty	148	18	40	8
Product 1—With warranty	237	29	96	20
Product 1—No purchase	—	—	22	5
Product 2—No warranty	99	12	21	4
Product 2—With warranty	163	20	83	18
Product 2—No purchase	—	—	13	3
No purchase	331	40	197	42
No. of times modal choice chosen				
2	26	3	2	0
3	175	18	35	7
4	271	28	89	19
5	204	21	114	24
6	122	13	82	17
7	100	11	47	10
8	80	8	39	8
9	—	—	40	8
10	—	—	24	5
No. of distinct choices made				
1	80	9	24	5
2	333	37	127	27
3	339	38	151	32
4	188	21	113	24
5	38	4	44	9
6	—	—	12	3
7	—	—	1	0

Notes. The table summarizes the distribution of modal choices, number of times modal choice is chosen, and the number of different choices made, across both surveys. The number of distinct choices are calculated as follows. In the simultaneous survey, subjects have five different possible choices. If, for example, a subject chose to buy the same product with or without warranty across all choice tasks, the subject would have made two distinct choices.

Figure 1 (Color online) Warranty Attachment Rate by Failure Probability



Notes. The figure shows the variation in warranty attachment rate (percentage of washer purchases associated with a warranty) with failure probability. The shaded area shows the 95% credibility region around the attachment rate.

3.3. Reduced-Form Results.

Table 4 reports results from logistic regressions based on the surveys. Focusing first on the simultaneous survey, we find that subjects have a lower preference for front-loading washing machines and almost equally prefer the two brands, which is consistent with the information provided in the survey. Subjects are almost four to five times as sensitive to expected repair costs ($c \cdot \pi$) and warranty prices, as compared to product price.[37] Respondents are almost equally sensitive to warranty prices and repair costs. Thus, we allow data to guide our model, and treat warranty prices as a loss, compared to product prices. If repair costs and product prices are measured from different (same) reference points, varying sensitivity to product prices and repair costs provides evidence for reference-dependent preferences (loss aversion). Without imposing more structure on the utility function, we cannot conclude whether these results are driven by loss-aversion or reference-dependent preferences. We also find evidence in favor of a nonlinear effect of failure probability on product (and warranty) purchase.

In the sequential survey, product price has a negative and significant effect on washer choice. Comparing the two stages of the sequential survey data, we again find that subjects are more sensitive to

[37] The qualitative findings stay the same even after we allow for higher-order terms of product and warranty prices (i.e., controlling for curvature).

Table 4 Reduced-Form Logistic Regressions

	Simultaneous survey	Sequential survey	
		Stage 1	Stage 2
GE	1.16	2.603	0.141
	(0.131)	(0.167)	(0.305)
GE + Warranty	2.19		1.892
	(0.168)		(0.277)
Whirlpool	1.271	2.915	0.159
	(0.133)	(0.169)	(0.306)
Whirlpool + Warranty	2.231		1.998
	(0.165)		(0.273)
Front loading	−0.055	−0.299	0.064
	(0.033)	(0.044)	(0.097)
Product price (p)	−0.194	−0.437	0.156
	(0.02)	(0.027)	(0.049)
Warranty price (ω)	−1.055		−1.395
	(0.109)		(0.218)
$c \cdot \pi$	−0.954		−1.146
	(0.219)		(0.367)
$c \cdot \pi^2$	−0.951		−0.103
	(0.64)		(1.067)
$c \cdot \pi^3$	1.009		0.614
	(0.475)		(0.784)
Log-likelihood	−11,862	−5,002	−2,895
AIC	23,745	10,011	5,810
No. of observations	7,824	4,719	3,113
Schwarz criterion	23,814	10,037	5,871

Notes. The table summarizes the parameter estimates from logistic regressions run on data using both simultaneous and sequential surveys. The standard errors are reported in parentheses. In addition to the estimates, the table also reports the log-likelihood, AIC, and the Schwarz criterion.

expected repair costs and warranty prices, as compared to product price. Subjects are also more likely to buy a warranty for more expensive washers, as can be seen from the positive and significant effect of washer price on warranty choice. Subjects have a high intrinsic preference for warranties and we do not find much nonlinear effect of failure probability. Taken together, these results provide evidence in support of loss aversion (and/or reference dependence) and mixed evidence for the nonlinear effect of failure probability.

4. Estimation Details

Given the relatively small panel, we make functional-form assumptions for the value and probability weighting functions. The functional-form assumptions are consistent across both surveys.[38] We use a power value function given by

$$v(y_{ij}^k) = \begin{cases} (y_{ij}^k)^{\gamma_i}; & y_{ij}^k \geq 0 \\ -\lambda_i(-y_{ij}^k)^{\gamma_i}; & y_{ij}^k < 0, \end{cases} \tag{18}$$

where gains and losses are measured with respect to the reference point. Specifically, preferences in the utility index are measured with respect to the individual reference point. Additionally, we assume the value function is symmetric around the reference point and has the same curvature in gains and losses. We make this assumption for convenience of estimation, and relaxing it does not change the qualitative findings.[39] Equation (18) implies a loss-aversion parameter given by $\lambda = -v(-1)/v(1)$, which is the most commonly used definition of loss aversion (Köbberling and Wakker 2005). Finally, we assume the weighting function follows a flexible parametric form given by $\delta_i(\pi_j) = \pi_j^{\mu_i}/(\pi_j^{\mu_i} + (1-\pi_j)^{\mu_i})^{1/\mu_i}$, where μ_i is a model parameter we estimate (Tversky and Kahneman 1992).

To operationalize the value function, we generalize Equations (6), (7), and (8) to define the utility index for the simultaneous survey as

$$y_{ij}^w = \alpha_{ij} + \alpha_{ij}^w + X_j\kappa_i - \beta_i(p_j + \lambda_i\omega_j), \tag{19}$$

$$y_{ij}^{nw} = \alpha_{ij} + X_j\kappa_i - \beta_i p_j, \tag{20}$$

$$y_{ij}^c = -\beta_i\lambda_i c_j, \tag{21}$$

where α_{ij} is the intrinsic consumption utility subject i gets from purchasing brand j and α_{ij}^w is the intrinsic preference for warranty purchased with brand j; κ_i is subject $i's$ preference for washer characteristic X (loading type) and β_i is subject $i's$ sensitivity to prices. As mentioned earlier, λ_i measures the asymmetric response to warranty price. The power value function provides an implicit normalization ($v(1) = 1$) that allows us to estimate the price coefficient β_i. The utility indices for the sequential survey are given by

$$y_{ij} = \alpha_{ij} + X_j\kappa_i - \beta_i p_j, \tag{22}$$

$$y_{ij}^w = \alpha_{ij}^w - \beta_i\lambda_i\omega_j, \tag{23}$$

$$y_{ij}^c = -\beta_i\lambda_i c_j. \tag{24}$$

To assess the impact of risk preferences, we estimate several other specifications restricting loss aversion, risk aversion, and reference dependence. The first two models are special cases of the *full* model in which we restrict either the risk-aversion parameter (γ_i) or the loss-aversion parameter (λ_i) to be 1. We call these models the *loss only* and *risk only* models, respectively. Both models allow for reference-dependent preferences and probability weights. We estimate a third *expected utility* model consistent with expected utility theory (not allowing for loss aversion and probability weights). Note that the *expected utility* model is not "nested" in the *full* model specification because of the presence of reference-dependent preferences.

Unlike von Gaudecker et al. (2011), we estimate the loss-aversion parameter freely. We estimate the curvature of the value function subject to the restriction $\gamma_i \geq 0$ to ensure the value function is monotonically increasing. Additionally, we restrict $\mu_i \geq 0$. We impose these restrictions by expressing the curvature and the weighting function parameter using an exponential transformation based on unrestricted parameters Γ_i and ρ_i such that $\gamma_i = \exp(\Gamma_i)$ and $\mu_i = \exp(\rho_i)$.[40] Let vector θ_i denote the subjects' taste parameters, $(\alpha_{ij,k}, \beta_i, \kappa_i, \Gamma_i, \rho_i, \lambda_i)$. We allow for heterogeneity by assuming the subjects' parameters are drawn from a common population normal distribution: $\theta_i \sim N(\bar{\theta}, V_\theta)$. Priors on the population hyperparameters, $\bar{\theta}$ and V_θ, are specified as follows:

$$\bar{\theta} \mid V_\theta \sim N(0, a^{-1}V_\theta), \tag{25}$$

$$V_\theta \sim IW(\nu, \nu I), \tag{26}$$

where $a = 1/16$ and $\nu = \dim(\theta_i) + 3$ are proper but very diffuse prior settings. We estimate the model using a hybrid Markov Chain Monte Carlo approach with a customized random-walk Metropolis step as discussed in Rossi et al. (2005) (Chapter 5).

5. Results

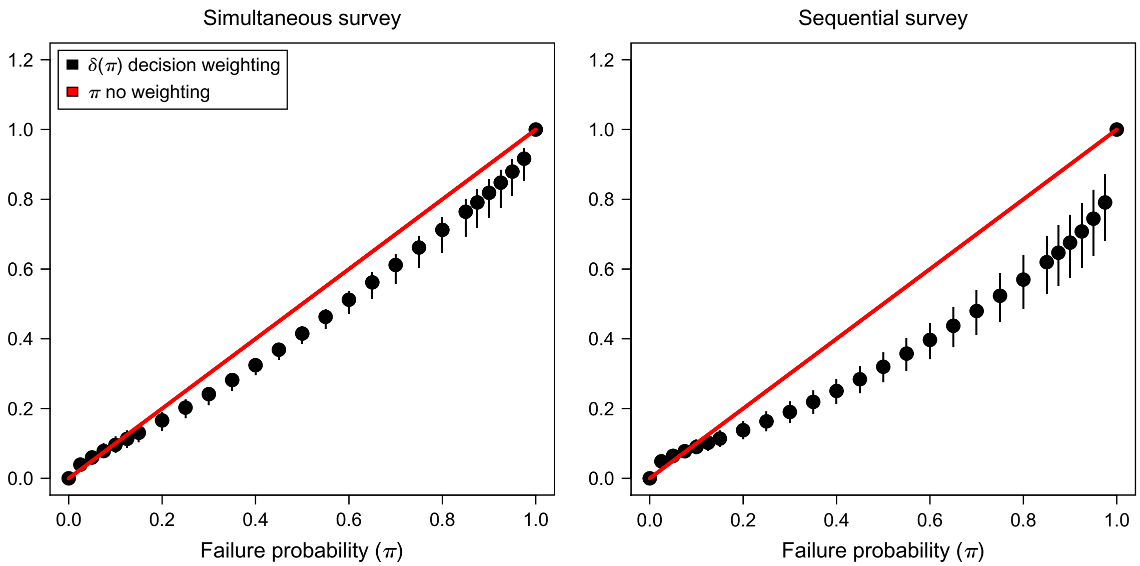
We now discuss the estimates from the models outlined in §§2 and 4. For each model, we report

[38] Robustness analysis for these assumptions (reported in the online appendix) do not change the qualitative findings.

[39] Please see the online appendix for further details.

[40] For *Expected utility* model $\gamma_i = \exp(\Gamma_i)/(1 + \exp(\Gamma_i))$.

Figure 2 (Color online) Decision Weighting Function of the Average Consumer Under Simultaneous and Sequential Survey



Notes. The figure displays the population means and 95% credibility regions for the decision-weighting function under simultaneous (left panel) and sequential (right panel) surveys. The 45-degree line corresponds to no-decision weighting (linearly account for probabilities).

results for both homogeneous and heterogeneous (normally distributed random coefficients) specifications. In each case, we report quantiles of the posterior distribution of the population hyper-parameters to assess the parameter magnitudes and precisions. We also report the log marginal density (computed using the Newton and Raftery 1994 approach) as well as a trimmed log marginal density in which we trim the upper and lower two percentile posterior draws to correct for outlier effects. Comparing log marginal densities across models is roughly equivalent to computing a Bayes factor to assess relative posterior model fit. For more details on the estimation of log marginal densities and Bayes factor, please refer to Rossi et al. (2005) (Chapter 6).

Simultaneous Survey. Table 5 reports results for all of the model specifications. Accounting for unobserved heterogeneity substantially improves the model fit. The *full* model fits the data substantially better than any of the alternate specifications. The *risk only* and *loss only* models fit the data worse than the baseline model, providing strong evidence against the restrictions $\lambda_i = 1$ and $\gamma_i = 1$. Both of these models outperform the *expected utility* model, which highlights the importance of accounting for reference dependence and loss aversion.

In the *full* model, subjects have a slightly concave value function with an average curvature parameter of $\gamma = 0.83$, but substantial heterogeneity exists in the curvature of the value function. The most important finding is the average loss-aversion estimate of 3.05. Although slightly on the higher side, the estimate is consistent with the literature in which the average loss aversion is estimated to be between 2 and 2.25. Further, we find substantial heterogeneity in the degree of loss aversion across subjects. The left panel of Figure 2 shows the weighting function and the 95% credibility region for the average consumer. The inverted *S*-shape is consistent with the findings in the literature. Finally, consistent with Peck and Shu (2009) and Ho et al. (2006), we find that subjects have a high intrinsic preference for warranties (peace of mind), which leads to a higher willingness to pay for warranties, and, along with risk preferences, rationalizes warranty choices.

Not allowing for loss aversion in the *expected utility* and *risk only* models leads to an upward bias in the price coefficient estimate. Restricting subjects to exhibit no loss aversion (*risk only* model) increases their preference for the washer, has an upward bias on price sensitivity, and changes the degree of curvature. However, assuming subjects have a linear value function (*loss only* model) does not affect washer and warranty preference or price sensitivity, and only marginally changes the sample distribution of loss aversion. To summarize, we find that (i) subjects are loss averse, (ii) substantial heterogeneity exists in risk preferences, and (iii) failure to decompose risk preferences leads to biased estimates of risk aversion (curvature), price sensitivity, and washer and warranty preference.

Sequential Survey. Table 6 reports results for all of the model specifications. Consistent with the simultaneous survey, we find the *full* model fits the data substantially better than the other specifications, and both *risk only* and *loss only* models outperform the *expected utility* model. Qualitatively, the estimates of

Table 5 Simultaneous Survey—Model Estimates

	Homogeneous tastes			Heterogeneous tastes: Pop. mean			Heterogeneous tastes: Pop. SD		
	2.5%	50%	97.5%	2.5%	50%	97.5%	2.5%	50%	97.5%
Full model									
α_{GE}	0.57	0.72	0.90	2.73	3.49	4.24	3.91	5.25	6.04
α_{GE}^{w}	0.39	0.49	0.56	1.59	2.04	2.52	2.89	3.36	3.93
α_{Wh}	0.59	0.75	0.96	2.94	3.71	4.48	4.06	5.40	6.37
α_{Wh}^{w}	0.39	0.48	0.55	1.38	1.84	2.36	2.84	3.31	3.80
Price (β)	0.12	0.14	0.18	0.39	0.48	0.57	0.46	0.56	0.64
Front loading (κ)	−0.07	−0.04	−0.01	−0.16	0.01	0.18	0.90	1.06	1.24
Probability weight (μ)	0.99	1.15	1.34	0.92	1.20	1.46	0.52	0.72	1.04
Curvature/risk (γ)	0.70	0.83	0.95	0.75	0.83	0.93	0.41	0.51	0.63
Loss aversion (λ)	1.92	2.39	2.90	2.72	3.05	3.61	1.49	1.72	2.14
Log marginal density		−11,989.44				−7,040.51			
Trimmed log m.d.		−11,987.79				−6,978.44			
Risk only model									
α_{GE}	1.25	1.50	1.77	3.42	4.73	5.76	5.43	6.70	7.79
α_{GE}^{w}	0.63	0.65	0.70	0.77	1.30	1.93	2.96	3.85	4.50
α_{Wh}	1.40	1.64	1.93	3.64	5.00	6.11	5.46	6.75	7.80
α_{Wh}^{w}	0.57	0.59	0.61	0.61	1.11	1.71	2.87	3.81	4.46
Price (β)	0.30	0.34	0.38	0.61	0.81	0.95	0.64	0.78	0.88
Front loading (κ)	−0.13	−0.07	−0.01	−0.25	−0.07	0.12	0.90	1.18	1.35
Probability weight (μ)	1.03	1.21	1.40	1.04	1.27	1.66	0.56	0.75	1.08
Curvature/risk (γ)	0.79	0.91	1.05	0.84	0.93	1.10	0.44	0.53	0.66
Log marginal density		−12,013.38				−7,459.83			
Trimmed log m.d.		−12,011.52				−7,400.83			
Loss only model									
α_{GE}	0.65	0.81	0.98	2.70	3.40	4.12	4.42	5.01	5.75
α_{GE}^{w}	0.59	0.62	0.68	1.68	2.08	2.47	2.67	3.02	3.43
α_{Wh}	0.70	0.87	1.09	2.92	3.64	4.41	4.49	5.11	5.82
α_{Wh}^{w}	0.57	0.60	0.59	1.55	1.93	2.31	2.50	2.86	3.25
Price (β)	0.13	0.16	0.19	0.37	0.44	0.51	0.43	0.48	0.55
Front loading (κ)	−0.08	−0.05	−0.02	−0.22	−0.08	0.05	0.84	0.95	1.08
Probability weight (μ)	1.01	1.16	1.33	0.97	1.22	1.54	0.53	0.71	1.02
Loss aversion (λ)	2.27	2.75	3.39	2.85	3.28	3.75	1.72	1.96	2.25
Log marginal density		−11,992.51				−7,091.35			
Trimmed log m.d.		−11,990.03				−7,040.71			
Expected utility model									
α_{GE}	1.32	1.56	1.80	4.15	5.46	6.85	7.03	8.82	10.73
α_{GE}^{w}	0.63	0.66	0.67	1.12	1.81	2.58	3.78	4.77	5.85
α_{Wh}	1.45	1.70	1.92	4.45	5.78	7.24	7.08	8.93	10.80
α_{Wh}^{w}	0.58	0.59	0.63	0.90	1.58	2.31	3.74	4.69	5.64
Price (β)	0.32	0.35	0.38	0.75	0.94	1.12	0.84	1.01	1.20
Front loading (κ)	−0.13	−0.07	−0.01	−0.31	−0.07	0.18	1.21	1.48	1.75
Curvature/risk (γ)	0.98	1.00	1.00	0.68	0.74	0.83	0.24	0.28	0.32
Log marginal density		−12,014.78				−7,483.78			
Trimmed log m.d.		−12,013.92				−7,430.77			

Notes. The table summarizes the parameter estimates from different models estimated using the simultaneous survey data. We report estimates from both the homogeneous and the heterogeneous models. For the homogeneous model, we report estimates corresponding to the 95% confidence region along with the median estimate. For the heterogeneous model, we report the same statistics for both the mean and the standard deviation of the distribution of population heterogeneity.

risk preferences are similar to those from the simultaneous survey. We find more heterogeneity in risk preferences, but on average, subjects have a loss-aversion estimate of 3.99 as compared to 3.05 in the simultaneous choice survey. Compared to the simultaneous survey, we find that subjects have a more convex value function. The right panel of Figure 2 shows the weighting function and the 95% credibility region for the average consumer. Again, consistent with the literature, on average, we find an inverted S-shaped

Table 6 Sequential Survey—Model Estimates

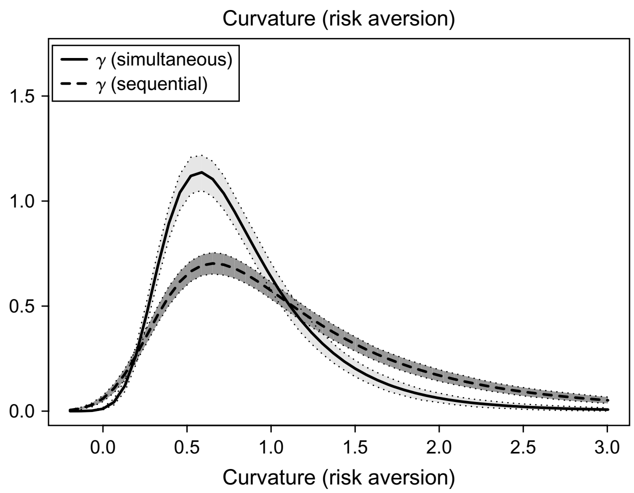
	Homogeneous tastes			Heterogeneous tastes: Pop. mean			Heterogeneous tastes: Pop. SD		
	2.5%	50%	97.5%	2.5%	50%	97.5%	2.5%	50%	97.5%
Full model									
α_{GE}	1.64	2.08	2.52	3.85	5.18	6.00	2.70	3.88	4.76
α_{GE}^{w}	1.05	1.25	1.42	2.69	3.70	4.77	2.88	3.93	4.96
α_{Wh}	1.89	2.37	2.85	4.18	5.57	6.40	2.54	3.61	4.42
α_{Wh}^{w}	1.09	1.26	1.43	2.50	3.39	4.43	2.66	3.64	4.67
Price (β)	0.27	0.34	0.42	0.53	0.73	0.86	0.51	0.64	0.76
Front loading (κ)	−0.34	−0.24	−0.15	−0.75	−0.36	0.00	2.02	2.53	3.04
Probability weight (μ)	1.05	1.85	3.55	1.07	1.48	2.36	0.96	1.83	5.23
Curvature/risk (γ)	0.73	0.99	1.28	1.12	1.32	1.77	0.74	1.04	1.59
Loss aversion (λ)	0.49	0.75	1.20	3.42	3.99	4.81	1.88	2.49	3.18
Log marginal density		−8,031.16				−3,601.14			
Trimmed log m.d.		−8,029.31				−3,558.50			
Risk only model									
α_{GE}	1.61	2.00	2.35	4.52	5.73	6.89	3.64	4.77	5.89
α_{GE}^{w}	1.18	1.31	1.44	1.30	1.82	2.39	2.49	3.13	3.92
α_{Wh}	1.86	2.29	2.65	4.90	6.16	7.31	3.37	4.41	5.52
α_{Wh}^{w}	1.19	1.32	1.44	1.17	1.61	2.10	2.24	2.86	3.44
Price (β)	0.26	0.32	0.37	0.72	0.91	1.08	0.59	0.75	0.92
Front loading (κ)	−0.32	−0.24	−0.16	−0.87	−0.41	0.05	2.52	3.07	3.58
Probability weight (μ)	1.18	1.90	3.26	1.00	1.39	2.24	0.86	1.41	2.97
Curvature/risk (γ)	0.87	1.10	1.35	1.33	1.55	2.20	0.88	1.22	2.27
Log marginal density		−8,034.67				−3,940.05			
Trimmed log m.d.		−8,029.05				−3,878.71			
Loss only model									
α_{GE}	1.71	2.10	2.51	5.64	6.60	7.64	4.83	5.72	6.75
α_{GE}^{w}	1.12	1.25	1.38	2.92	3.61	4.38	3.55	4.23	5.02
α_{Wh}	1.98	2.40	2.85	6.17	7.12	8.16	4.68	5.61	6.67
α_{Wh}^{w}	1.14	1.26	1.39	2.69	3.33	4.02	3.16	3.76	4.45
Price (β)	0.27	0.34	0.42	0.81	0.95	1.10	0.65	0.77	0.90
Front loading (κ)	−0.33	−0.25	−0.16	−0.92	−0.47	−0.04	2.67	3.07	3.54
Probability weight (μ)	1.08	1.84	3.56	0.88	1.34	2.16	0.84	1.58	3.36
Loss aversion (λ)	0.54	0.77	1.09	2.83	3.43	4.13	2.53	3.04	3.71
Log marginal density		−8,031.92				−3,704.90			
Trimmed log m.d.		−8,028.64				−3,650.85			
Expected utility model									
α_{GE}	0.99	1.43	1.77	7.71	9.42	11.42	7.16	8.43	10.05
α_{GE}^{w}	0.99	1.17	1.33	2.14	3.15	4.39	4.49	5.75	7.44
α_{Wh}	1.10	1.57	1.95	8.37	10.10	12.17	6.91	8.14	9.71
α_{Wh}^{w}	1.21	1.39	1.61	1.90	2.79	3.80	4.05	5.11	6.53
Price (β)	0.16	0.23	0.28	1.21	1.48	1.78	0.97	1.17	1.39
Front loading (κ)	−0.25	−0.18	−0.11	−1.35	−0.60	0.10	4.28	4.92	5.66
Curvature/risk (γ)	0.49	0.62	0.73	0.71	0.78	0.85	0.18	0.24	0.28
Log marginal density		−8,016.33				−4,069.22			
Trimmed log m.d.		−8,013.69				−4,027.17			

Notes. The table summarizes the parameter estimates from different models estimated using the sequential survey data. We report estimates from both the homogeneous and the heterogeneous models. For the homogeneous model, we report estimates corresponding to the 95% confidence region along with the median estimate. For the heterogeneous model, we report the same statistics for both the mean and the standard deviation of the distribution of population heterogeneity.

weighting function. As in the simultaneous choice survey, not allowing for reference dependent preferences and/or loss aversion overestimates sensitivity to product prices, which has important managerial consequences as we show in §6.

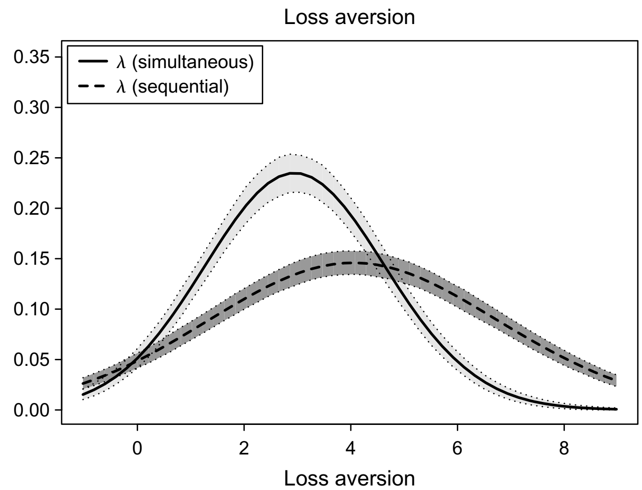
In Figures 4 and 3, we report the posterior marginal density and the 90% credibility region of the value function curvature (γ) and loss aversion (λ) for the simultaneous and sequential surveys, respectively. We find more heterogeneity in the estimate of value

Figure 3 **Distribution of Value Function Curvature Under Simultaneous and Sequential Survey**



Notes. The graph displays the pointwise posterior mean and 90% credibility region of the marginal density of the risk-aversion (curvature) coefficient γ from the full model based on both the simultaneous and sequential choice surveys. Under prospect theory, risk aversion and convex value function can coexist. Thus, we estimate γ subject to only the restriction $\gamma > 0$.

Figure 4 **Distribution of Loss Aversion Under Simultaneous and Sequential Survey**



Notes. The graph displays the pointwise posterior mean and 90% credibility region of the marginal density of the loss-aversion parameter λ from the full model based on both the simultaneous and sequential choice surveys. We estimate the loss aversion-parameter freely.

function curvature and loss aversion in the sequential choice survey, which can be attributed to fewer choices per subject in the sequential survey.

Relative Importance of Risk Preferences. We test for the relative importance of risk preferences in two different ways. For both tests, we estimate models on a subset of data and randomly select around five to six choices per subject for the holdout sample. We then use demand estimates based on the subsample to test out-of-sample fit. Table 7 presents results from out-of-sample predictions made using data from the two surveys.

First, we assess and compare the importance of curvature and loss aversion in the *risk only* and *loss only* models, respectively. Focusing on columns 1 and 4, the out-of-sample hit rate (percentage of correct predictions) for the *risk only* model is 55% and 64% for the simultaneous and sequential surveys, respectively. Product and price preferences correctly predict 55% (63%) of the choices.[41] Therefore, risk preferences (curvature and probability weights) in the *risk only* model only marginally improve the model prediction. By contrast, loss aversion and probability weights improve the *loss only* model prediction by 8% (56%–48%) and 5% (67%–62%) for the simultaneous and sequential surveys, respectively, providing evidence of the relative importance of loss aversion in predicting choices. This effect is more pronounced if we compare the effect of risk preferences on warranty choices (columns 3 and 6). Not allowing for loss aversion in the *loss only* model has a bigger impact on the hit rate than not allowing for risk aversion in the *risk only* model. When subjects do not purchase warranties (columns 2 and 5), risk preferences do not substantially affect the hit rate.

Second, we study how adding risk preferences to the *full* model improves model predictions. We first use all of the demand estimates to make out-of-sample predictions. Consequently, we assume $\gamma_i = \lambda_i = \mu_i = 1$ and only use product and price preferences to make out-of-sample predictions. Intuitively, the difference in accuracy between these two predictions can be attributed to risk aversion, loss aversion, and probability weights. We then take turns "switching on" each of these parameters one at a time and report the out-of-sample predictions. In the lower panel of Table 7, we report the model prediction for all choices, and by warranty and no warranty purchases separately. For the simultaneous survey, adding curvature or probability weights does not improve prediction, whereas adding loss aversion improves prediction from 50% to 53%. This finding again provides evidence of the relative importance of loss aversion as compared to curvature and probability weights. Similarly, in the sequential study, adding loss aversion improves prediction more than adding either curvature or probability weights. Together these two tests provide substantial evidence that loss aversion is significantly more important than risk aversion (curvature) and probability weights in explaining warranty choices.

[41] We make out-of-sample predictions using only product and price preferences by marginalizing out the distribution of risk preferences.

Table 7 Relative Importance of Risk Preferences in Out-of-Sample Predictions

	Simultaneous survey			Sequential survey		
Hit rate (% choices correctly predicted)	All choices (1)	No warranty purchase (2)	Warranty purchase (3)	Final choice (4)	First stage product choice (5)	Warranty choice (6)
			Risk only model			
All preferences	55%	60%	48%	64%	72%	88%
Product and price preferences only	55%	59%	48%	63%	73%	86%
			Loss only model			
All preferences	56%	62%	48%	67%	77%	87%
Product and price preferences only	48%	59%	33%	62%	76%	81%
			Full model			
All preferences	55%	59%	49%	67%	77%	87%
Product and price preferences only	50%	58%	39%	58%	73%	80%
Additional preferences						
Risk aversion only	49%	61%	32%	60%	74%	81%
Loss aversion only	53%	53%	52%	64%	76%	84%
Probability weights only	50%	57%	39%	61%	78%	79%
Loss aversion and probability weights	53%	54%	51%	67%	77%	87%

Notes. The table reports results from the out-of-sample predictions based on the baseline model and alternate specifications, on both simultaneous and sequential survey data. Additionally, the accuracy of out-of-sample predictions (hit rate) is split by choices where warranty was chosen versus not for the simultaneous survey, and by first- versus second-stage choices for the sequential survey.

6. Pricing Implications

We use the demand estimates from *full* and *expected utility* models to understand the pricing implications of decomposing different risk preferences. As compared to a standard conjoint analysis, the structure of our model allows us to understand choices a rational consumer would make, and how consumers would respond to different pricing policies. Specifically, we use the model structure to address how risk preferences affect pricing and firm profits, and study the impact of risk preferences on the premia paid for warranties. Finally, we do counterfactual analysis to understand whether warranties should be sold only through independent retailers.

Managerial Implications. In the previous section, we found that failure to decompose risk preferences results in an upward bias in price sensitivity and washer and warranty preference. Intuitively, more price sensitive consumers will reduce the retailers' pricing power and adversely affect profits. We now quantify the effect of biased estimate of price sensitivity on washer prices and firm profits. To do so, we consider a monopolist who sells only the GE washer and consumers have the option of purchasing it with or without a warranty or choosing the outside option of no purchase. We compare optimal washer prices, and profits based on the *full* model with those based on the *expected utility* model.[42] Firms can vary the washer and warranty prices, and repair costs (to the consumer) such that the optimal profits remain unchanged. Thus, we cannot jointly maximize profits over these prices and costs simultaneously. Assuming that the firm charges marginal cost for product repair and extended warranty, the firms profit as a function of washer price (p) is given by

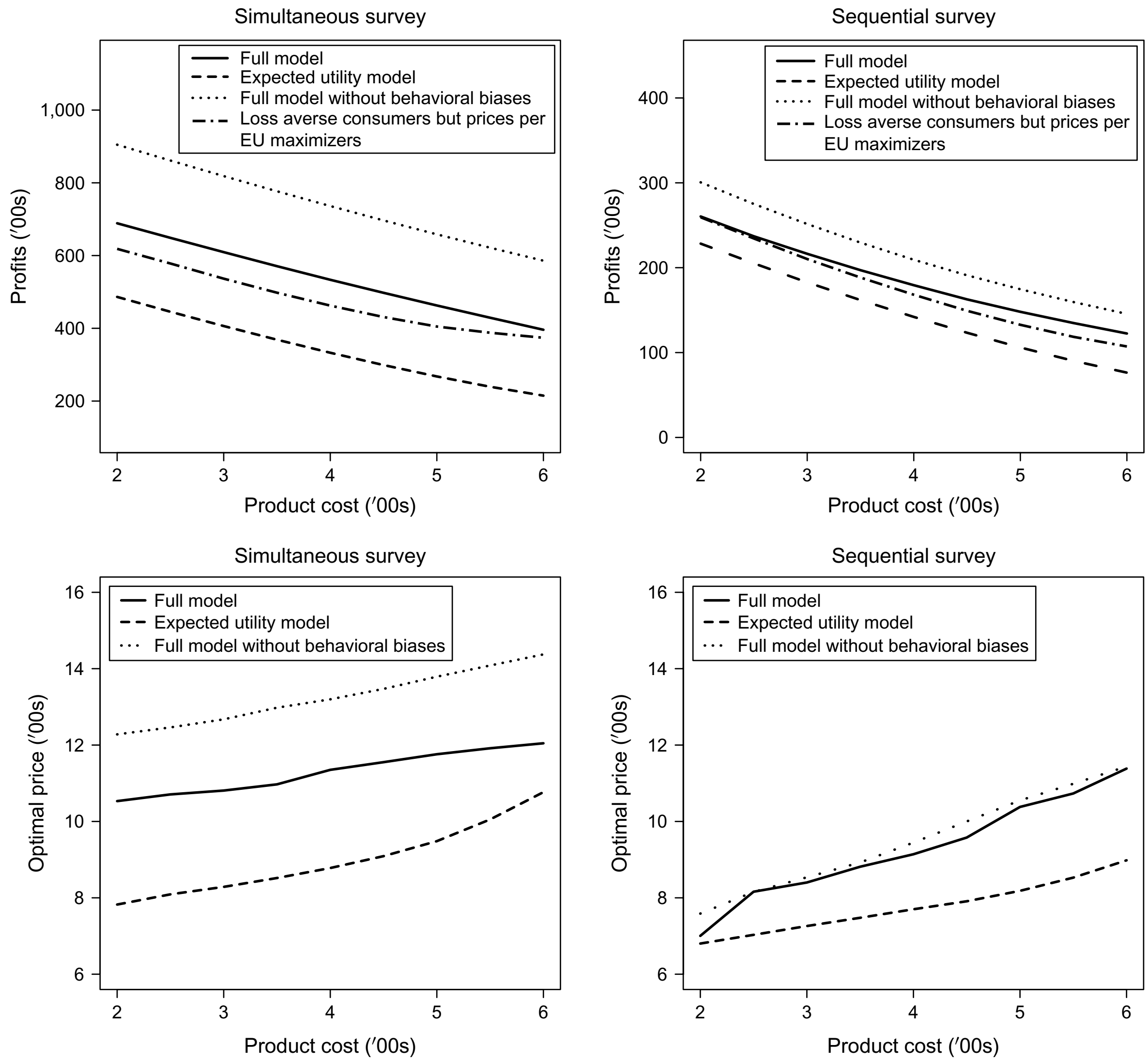
$$\Pi(p) = (p - c_p) \int \big[\mathbb{D}_{\mathbb{P}}(\theta; p, c_r, \pi) + \mathbb{D}_{\mathbb{W}}(\theta; p, p_w, c_r, \pi)\big] f(\theta)\, d\theta, \qquad (27)$$

where c_p is the product cost to the retailer, c_r is the repair cost to the consumer, π is the failure probability, $\mathbb{D}_{\mathbb{P}}(\cdot)$ is the demand for washer (only), and $\mathbb{D}_{\mathbb{W}}(\cdot)$ is the demand for washer with warranty. Optimal prices and profits corresponding to the *expected utility* model form a benchmark for comparing pricing and profits under alternate preferences/models.

The bottom panel of Figure 5 shows that in the simultaneous (sequential) survey, higher price sensitivity and biased washer and warranty preferences lead to roughly 16% (20%) lower washer prices under the *expected utility* model as compared to the *full* model. Relieving consumers of their behavioral bias reduces risk-averse behavior and allows retailers to charge a 17% (3%) higher price (as compared to the *full* model) for the washer in the simultaneous (sequential) study. The top panel of Figure 5 shows the optimal profits under different models, for both simultaneous and sequential surveys. We focus on the sequential survey in the interest of space. First, pricing to *expected utility* maximizers results in around 23% lower profit as compared to the *full* model. Second, if consumers are relieved of their behavioral bias, the higher washer price results in around 17% more

[42] This analysis is descriptive in the sense that we do not account for income effects.

Figure 5 **Optimal Washer Prices (GE) and Retailer Profits Under Simultaneous and Sequential Surveys**



Notes. The figure shows the optimal washer prices ($'00s) and corresponding profits ($'00s) for a monopolist retailer, for a wide range of washer costs. The left (right) panel shows results from the simultaneous (sequential) survey, and the top (bottom) panel shows the optimal profits (washer prices). These prices have been calculated assuming the retailer sells both washers and warranties, but makes profit only from washers. The figures show the optimal prices and profits using estimates from the full model (and assuming that consumers are loss averse and have reference-dependent preferences), from the expected utility model (and assuming that consumers are expected utility maximizers), and from the full model but after eliminating behavioral biases (loss aversion and decision weighting). Additionally, the figures also show the optimal retailer profits if the retailer sets prices assuming consumers are expected utility maximizers but the consumers behave consistent with the full model.

profits. Finally, if the retailer sets prices assuming expected utility maximizers, but subjects are instead loss averse and behave per the *full* model, profits are on average 6% lower.

In the online appendix, we study robustness of optimal washer pricing to different assumptions of reference points.[43] Although we find some differences in prices implied by different reference point assumptions, overall, for any chosen reference point, the optimal prices are higher than those implied by the expected utility benchmark, which ensures that assumptions about reference point(s) do not drive our substantive findings.

Complementary Goods and Price Discrimination. As with razors and blades, retailers may have an

[43] The current analysis assumes that reference points are defined consistently (and independently) across each choice task. If consumers update their reference point based on characteristics shown in previous choice tasks, then, as Tversky and Kahneman (1991) show, failure to recognize this updating may lead to intersecting indifference curves and nonunique optimal prices. We believe understanding how consumers update their reference points across different choice tasks in a conjoint study is extremely valuable but beyond the scope of the current research.

Table 8 **Test Theory on Price Discrimination (Single Crossing Property)**

	Simultaneous survey			Sequential survey		
	2.5%	50%	97.5%	2.5%	50%	97.5%
Marginal demand (z^*)[a]	55%	59%	62%	22%	27%	33%
Average demand ($\bar{z}$)	56%	59%	61%	64%	65%	67%
Difference ($\bar{z} - z^*$)	−3%	0%	3%	32%	38%	44%

Notes. The table summarizes results from the test of the single crossing property, for both simultaneous and sequential surveys. The table reports the 95% confidence region as well as the median estimate for the likelihood that the marginal washing machine consumer buys a warranty, the average likelihood of buying a warranty among all of the washing machine consumers, and their difference.

[a]Assumes washer price of $599, warranty price of $99, repair costs of $249, and failure probability of 25%. These numbers are consistent with the average failure rate and prices as per Consumer Reports, and observed in practice.

incentive to price discriminate among consumers buying washers and warranties. We test retailers' incentives to price discriminate and whether price discrimination leads to the high premia consumers routinely pay for extended warranties. Oi (1971) and Rosen and Rosenfield (1997) outline the econometric condition (subject to some assumptions) under which it is optimal for a firm to charge a premium on aftermarket goods (e.g., extended warranties). Let θ be a vector of product and risk preferences, and $\theta^*(p)$ denote the marginal consumer who is indifferent between buying and not buying the washer at any price p. In the context of washers and warranties, the econometric condition can be written out as

$$\Pr(\mathbb{I}(\mathit{warranty}) = 1 \mid \theta^*(p)) < \mathbb{E}[\Pr(\mathbb{I}(\mathit{warranty}) = 1 \mid \theta) \mid v(p;\theta) > v(p;\theta^*(p))], \tag{28}$$

where $v(p;\theta)$ is the value a subject with preference vector θ gets from buying the washer at price p. Equation (28), also known as the single crossing property, implies a firm should charge high markups on extended warranties if, at any washer and warranty price, the probability that the marginal washing machine consumer buys the warranty is lower than the average probability of warranty purchase among all of the consumers who buy the washing machine at that price. Intuitively, Equation (28) tests for correlation between preference estimates that drive warranty choices and willingness to pay for the washer. Let $z^* = \Pr(\mathbb{I}(\mathit{warranty}) = 1 \mid \theta^*(p))$ and $\bar{z} = \mathbb{E}[\Pr(\mathbb{I}(\mathit{warranty}) = 1 \mid \theta) \mid v(p;\theta) > v(p;\theta^*(p))]$. Conversely, if $z^* = \bar{z}$, firms should instead charge a higher markup on the washing machine and sell warranties at marginal cost.[44]

Table 8 reports the quantiles for the distribution of $\bar{z}$, z^*, and $\bar{z} - z^*$ from both surveys. For the simultaneous choice survey, we find the distribution of the $\bar{z} - z^*$ is centered around 0, implying selling warranties at marginal cost. By contrast, for the sequential choice survey, the distribution of $\bar{z} - z^*$ has a median value of 38%, implying selling extended warranties at a premium. Recalculating the monopolist profit-maximizing prices (while allowing for profits from selling warranties) using the sequential choice data, we find it is optimal to sell extended warranties at a contribution margin of 78% with a price equal to roughly 21% of the product price. Although slightly higher, this finding is consistent with the warranty margins in Table 1. Also, the warranty price as a percentage of the product price is consistent with the industry average (15%–25%). Thus, although warranty purchases can be rationalized through risk preferences (and intrinsic preference for warranties), rationalizing the premium paid for warranties requires looking at the correlation between these preferences and the willingness to pay for the washer.[45]

Welfare Changes from Policy Intervention. We now estimate the discount on the washer price (measure of compensating variation) that makes subjects indifferent between the current policy (in which a retailer sells both washers and warranties) and a policy in which separate retailers sell washers and warranties. Focusing on the sequential survey, we calculate the optimal washer price for a monopolist selling only the washer (warranty price is irrelevant to this pricing decision). Given the optimal washer price, some assumed repair costs and failure probability, we maximize profits with respect to the warranty price for a monopolist selling only warranties. The washer price determines the distribution of preferences the retailer selling warranties faces and is relevant to warranty pricing. We calculate compensating variation by equating the expected maximum utility before and after the policy change.

Forcing separate retailers to sell washers and warranties increases the washer price by 7% and reduces

[44] As in Gil and Hartmann (2009), we satisfy the underlying assumptions by assuming away income effects, which is standard in the discrete choice literature.

[45] To test whether model specification implicitly drives the high premia in the sequential choice study, we reestimated the sequential choice model on data from the simultaneous choice survey. Profit maximization from the demand estimates indicates only a modest increase in markup for extended warranties. Therefore, the high markup cannot entirely be attributed to model specification.

the warranty price by 3%.[46] On average, subjects need to receive a discount of $36 (3.4%) on the washer price to make them indifferent to the policy intervention.[47] We find substantial heterogeneity in the discount, but almost all subjects are worse off under the new policy, so forcing separate retailers to sell washers and warranties is not necessarily welfare enhancing.

7. Discussion and Conclusion

This paper contributes to the growing stream of literature on product insurance and inference using stated preference data. It is gratifying to know that a burgeoning literature applies structural models to conjoint analysis and stated preference data in contexts in which field data either do not exist or pose several limitations. We design surveys that allow for nonparametric identification of risk preferences (curvature, loss aversion, and probability weights) and product preferences, consequently alleviating the need to rely on strong parametric assumptions. We compare washer and warranty purchase decisions under two different choice mechanisms and consistently find evidence that loss aversion explains warranty purchases substantially more than curvature of the utility function and nonlinear probability weights do. Subjects exhibit substantial heterogeneity in loss aversion with an average loss-aversion parameter of 3.05 (3.99) in the simultaneous (sequential) survey. We find heterogeneity in curvature of utility function and probability weights, but these preferences explain only a small fraction of consumer choices as compared to loss aversion. These findings are robust to different specifications of the value function, probability weighting function, and reference point. A Bayesian model selection test based on the demand estimates rejects models that do not account for loss aversion and/or reference-dependent preferences.

Decomposing risk preferences has important managerial implications. First, not accounting for loss aversion, we underpredict washer prices, which leads to on average 23% lower firm profits. Correlations between subjects willingness to pay for the washer and risk preferences (which drive demand for warranties) also have important implications for pricing and selling warranties. Forcing separate retailers to sell washers and warranties leads to an increase (decrease) in the washer (warranty) price, making almost all subjects worse off. The use of a representative and knowledgeable pool of subjects ensures not only internal but also external validity of our findings.

[46] Assumes washer costs $500, repair cost equals $200, and failure probability is 25%.

[47] Robustness checks on assumed washer cost, repair cost, and failure probability yield similar results.

Several directions exist for future research based on the findings herein. First, in the surveys, subjects are provided failure probabilities and repair costs. Thus, a priori, subjects' beliefs are known to the researcher. In practice, warranty purchases are based on (and possibly driven by) the beliefs consumers have about product failure and repair costs. A possible extension would be to elicit consumers' beliefs and integrate out over their distribution to study warranty choice. Second, in our surveys, we offer subjects a single extended warranty. In practice, consumers have access to a menu of warranties varying not only in duration but also in the depth of coverage. Another interesting extension would be to design the optimal warranty contracts while accounting for consumers' elicited beliefs.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mksc.2014.0879.

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References

Abdellaoui M (2000) Parameter-free elicitation of utility and probability weighting functions. *Management Sci.* 46(11):1497–1512.

Abdellaoui M, Bleichrodt H, L'Haridon O (2008) A tractable method to measure utility and loss aversion under prospect theory. *J. Risk Uncertainty* 36(3):245–266.

Abdellaoui M, Bleichrodt H, Paraschiv C (2007) Loss aversion under prospect theory: A parameter-free measurement. *Management Sci.* 53(10):1659–1674.

Barseghyan L, Molinari F, O'Donoghue T, Teitelbaum JC (2013) The nature of risk preferences: Evidence from insurance choices. *Amer. Econom. Rev.* 103(6):2499–2529.

Bell DR, Lattin JM (2000) Looking for loss aversion in scanner panel data: The confounding effect of price response heterogeneity. *Marketing Sci.* 19(2):185–200.

Booij AS, van de Kuilen G (2009) A parameter-free analysis of the utility of money for the general population under prospect theory. *J. Econom. Psych.* 30(4):651–666.

Bronnenberg BJ, Wathieu L (1996) Asymmetric promotion effects and brand positioning. *Marketing Sci.* 15(4):379–394.

Bruhin A, Fehr-Duda H, Epper T (2010) Risk and rationality: Uncovering heterogeneity in probability distortion. *Econometrica* 78(4):1375–1412.

Bryant WK, Gerner JL (1982) The demand for service contracts. *J. Bus.* 55(3):345–365.

Chen T, Kalra A, Sun B (2009) Why do consumers buy extended service contracts? *J. Consumer Res.* 36(4):611–623.

Chu J, Chintagunta P (2009) Quantifying the economic value of warranties in the U.S. server market. *Marketing Sci.* 28(1): 99–121.

Cohen A, Einav L (2007) Estimating risk preferences from deductible choice. *Amer. Econom. Rev.* 97(3):745–788.

Dubé J-P, Hitsch GJ, Jindal P (2014) The joint identification of utility and discount functions from stated choice data: An application to durable goods adoption. *Quant. Marketing Econom.*, ePub ahead of print, September 10, link.springer.com/article/10.1007/s11129-014-9149-3.

Erdem T, Mayhew G, Sun B (2001) Understanding reference-price shoppers: A within- and cross-category analysis. *J. Marketing Res.* 38(4):445–457.

Gächter S, Johnson EJ, Herrmann A (2010) Individual-level loss aversion in riskless and risky choices. CeDex discussion paper 2010-20, http://www.econstor.eu/dspace/bitstream/10419/49656/1/640944027.pdf.

Gil R, Hartmann WR (2009) Empirical analysis of metering price discrimination: Evidence from concession sales at movie theaters. *Marketing Sci.* 28(6):1046–1062.

Gonzalez R, Wu G (1999) On the shape of the probability weighting function. *Cognitive Psych.* 38(1):129–166.

Hardie BGS, Johnson EJ, Fader PS (1993) Modeling loss aversion and reference dependence effects on brand choice. *Marketing Sci.* 12(4):378–394.

Harrison GW, List JA, Towe C (2007) Naturally occurring preferences and exogenous laboratory experiments: A case study of risk aversion. *Econometrica* 75(2):433–458.

Ho TH, Lim N, Camerer CF (2006) Modeling the psychology of consumer and firm behavior with behavioral economics. *J. Marketing Res.* 43(3):307–331.

Ho T-H, Zhang J (2008) Designing pricing contracts for boundedly rational customers: Does the framing of the fixed fee matter? *Management Sci.* 54(4):686–700.

Hotz VJ, Miller RA (1993) Conditional choice probabilities and the estimation of dynamic models. *Rev. Econom. Stud.* 60(3): 497–529.

Huysentruyt M, Read D (2010) How do people value extended warranties? Evidence from two field surveys. *J. Risk Uncertainty* 40(3):197–218.

Jarnebrant P, Toubia O, Johnson EJ (2009) The silver lining effect: Formal analysis and experiments. *Management Sci.* 55(11): 1832–1841.

Kahneman D, Tversky A (1979) Prospect theory: An analysis of decision under risk. *Econometrica* 47(2):263–291.

Köbberling V, Wakker PP (2005) An index of loss aversion. *J. Econom. Theory* 122(1):119–131.

Kőszegi B, Rabin M (2006) A model of reference-dependent preferences. *Quart. J. Econom.* 121(4):1133–1165.

Kunreuther H, Pauly M (2006) *Insurance Decision Making and Market Behavior (Foundations and Trends in Microeconomics)* (Now Publishers Inc, Delft, The Netherlands).

Newton MA, Raftery AE (1994) Approximate Bayesian inference with the weighted likelihood bootstrap. *J. Royal Statist. Soc. Ser. B* (*Methodological*) 56(1):3–48.

Novemsky N, Kahneman D (2005) The boundaries of loss aversion. *J. Marketing Res.* 42(2):119–128.

Oi WY (1971) A Disneyland dilemma: Two-part tariffs for a Mickey Mouse monopoly. *Quart. J. Econom.* 85(1):77–96.

Padmanabhan V (1995) Usage heterogeneity and extended warranty. *J. Econom. Management Strategy* 4(1):33–53.

Padmanabhan V, Rao RC (1993) Warranty policy and extended service contracts: Theory and an application to automobiles. *Marketing Sci.* 12(3):230–247.

Peck J, Shu SB (2009) The effect of mere touch on perceived ownership. *J. Consumer Res.* 36(3):434–447.

Rabin M, Thaler RH (2001) Anomalies: Risk aversion. *J. Econom. Perspect.* 15(1):219–232.

Rosen S, Rosenfield AM (1997) Ticket pricing. *J. Law Econom.* 40(2):351–376.

Rossi PE, Allenby GM, McCulloch R (2005) *Bayesian Statistics and Marketing.* Wiley Series in Probability and Statistics (John Wiley & Sons, Ltd., Chichester, UK).

Schoemaker PJH, Kunreuther HC (1979) An experimental study of insurance decisions. *J. Risk Insurance* 46(4):603–618.

Soberman DA (2003) Simultaneous signaling and screening with warranties. *J. Marketing Res.* 40(2):176–192.

Sydnor J (2010) (Over)insuring modest risks. *Amer. Econom. J.: Appl. Econom.* 2(4):177–199.

Thaler RH (1985) Mental accounting and consumer choice. *Marketing Sci.* 4(3):199–214.

Tversky A, Kahneman D (1991) Loss aversion in riskless choice: A reference-dependent model. *Quart. J. Econom.* 106(4):1039–1061.

Tversky A, Kahneman D (1992) Advances in prospect theory: Cumulative representation of uncertainty. *J. Risk Uncertainty* 5(4):297–323.

von Gaudecker H-M, van Soest A, Wengström E (2011) Heterogeneity in risky choice behavior in a broad population. *Amer. Econom. Rev.* 101(2):664–694.

Wakker P, Thaler R, Tversky A (1997) Probabilistic insurance. *J. Risk Uncertainty* 15(1):7–28.

Williamson J, Ranyardy R, Cuthbertz L (2000) Risk management in everyday insurance decisions: Evidence from a process tracing study. *Risk Decision Policy* 5(1):19–38.

Winer RS (1986) A reference price model of brand choice for frequently purchased products. *J. Consumer Res.* 13(2):250–256.