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Willingness to Pay for Insurance in Denmark

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Abstract

We estimate how much Danish households are willing to pay for auto, home, and house insurance. We use a unique combination of claims data from a large Danish insurance company, measures of individual risk attitudes and discount rates from a field experiment with a representative sample of the adult Danish population, and information on household income and wealth from registers at Statistics Denmark. The results show that the willingness to pay is marginally higher than the actuarially fair value under expected utility theory, but significantly higher under rank-dependent utility theory, and up to 600 percent higher than the actuarially fair value.

There is no simple way to measure the economic value of insurance products because the primary use of these products deals with the control of risk. Some studies attempt to estimate the willingness to pay for insurance products using contingent valuation or stated choice methods that are based on hypothetical questions, while other studies attempt to estimate risk preferences from data on insurance claims and deductible choices (Cohen and Einav, 2007).[1] Contingent valuation and stated choice methods are based on survey questions with no real purchase or consumption consequences for the participants. These methods may thus attract a "hypothetical bias," which is measured as the divergence between the real and hypothetical willingness to pay. There is widespread evidence of participants in contingent valuation studies to overstate the amount they are willing to pay for an incremental unit of private goods (Cummings, Harrison, and Rutstrom, 1995; List and Gallet, 2001; Murphy et al., 2005; Blumenschein et al., 2008).

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[1] See Harrison and Martinez-Correa (2012) for a systematic overview of the literature on behavioral insurance.

We estimate the willingness to pay among Danish households for three types of insurance using a unique combination of claims data from the largest Danish insurance company, Tryg A/S, register-based data from Statistics Denmark, and measures of individual risk attitudes and discount rates from a field experiment with a representative sample of the adult Danish population. These field experiments were carried out under the auspices of the Danish Ministry of Economic and Business Affairs, and the incentives in these experiments are comparable to the average claims on auto, home, and house insurance products that we consider in this study.

The estimated willingness to pay for insurance is based on a decision problem in which the decision maker maximizes expected intertemporal utility subject to an intertemporal budget constraint. The model is calibrated to claims data in 2004 from the customer database at Tryg, and these data are mapped to information at Statistics Denmark on annual household income and financial wealth. Since potential insurance claims may be substantial in comparison to annual income, and the probability of filing a claim is relatively small, it is appropriate to allow for consumption smoothing over a longer time period and thereby reduce the impact of an accident on consumption in the short term.

We use experimental data from a field methodology developed by Harrison et al. (2005) to elicit both risk and time preferences from the same respondents. The experimental procedures build on the risk aversion experiments of Holt and Laury (2002) and the discount rate experiments of Coller and Williams (1999) and Harrison, Lau, and Williams (2002). Data were collected in the field in Denmark in June 2003 to obtain a sample that offers a wider range of individual sociodemographic characteristics than usually found in subject pools recruited in colleges, as well as a sample that can be used to make inferences about the preferences of the adult population of Denmark. These experiments are "artifactual field experiments" in the terminology of Harrison and List (2004), since lab experiments are essentially taken to field subjects. Economists recognize that preferences can differ across individuals, but only a few attempts have been made to elicit individual preferences for representative samples of a population in a particular geographical area, region, or country.[2]

[2]Harrison, Lau, and Williams (2002) elicit individual discount rates for a representative sample of the adult Danish population and find evidence of significant preference heterogeneity across sociodemographic variables. This is the first attempt to elicit individual preferences of a population in a country using controlled experiments with monetary rewards. Eckel, Johnson, and Montmarquette (2005) conduct a field study of time and risk preferences. Their subjects were recruited from low-income neighborhoods in Montreal, and they were given 64 "compensated" questions, one of which was chosen at random for payment. Dohmen et al. (2011) elicit individual risk attitudes and combine hypothetical surveys with experiments that involve monetary incentives. A total of 450 subjects participated in the experiment, and they were recruited from 179 randomly chosen voting districts in Germany. Andersen et al. (2010) examine the strengths and weaknesses of laboratory and field experiments to detect differences in preferences over risk and time that are associated with standard, observable characteristics of the individual.

We discuss the elicitation of risk and time preferences in the "Eliciting Risk and Time Preferences" section, and the estimation of these preferences in the "Identifying Risk and Time Preferences" section. The demand for insurance is discussed in the "Estimating Willingness to Pay" section, along with a presentation of the claims data in the "Insurance Data" section, and the estimated willingness to pay for auto, home, and house insurance in the "WTP for Auto, Home, and House Insurance" section. We consider the effects of alternative probability weighting functions on estimated WTP in the "Probability Weighting" section, and conclude in the "Conclusions" section.

ELICITING RISK AND TIME PREFERENCES

Information on individual risk attitudes and discount rates is obtained from Harrison et al. (2005). The sample for the field experiments was designed to generate a representative sample of the adult Danish population between 19 and 75 years of age. A total of 664 invitations were mailed out to a stratified sample of the adult population. Everyone who gave a positive response was assigned to a session, and the recruited sample was 268, corresponding to a response rate of 40 percent. The experiments were conducted in June 2003, and a final sample of 253 subjects provided data.

Risk Preferences: Measuring Risk Aversion

Harrison et al. (2005) used a multiple price list (MPL) design to elicit individual risk attitudes.[3] They used the same approach as in Holt and Laury (2002) and presented an ordered array of binary lottery choices to be made at once. The subject picked one of the two lotteries in each row of the MPL, played out the chosen lottery and received the reward. Each subject responded to four separate risk aversion tasks, each with different prizes designed so that all 16 prizes span an income interval from 50 kroner to 4,500 kroner.[4] One task and one row were picked at random for payment, and each subject was given a 10 percent chance to actually receive the payment associated with his or her decision.[5]

[3]Andersen et al. (2006) examine the properties of the MPL procedure in detail, and the older literature using it. Harrison and Rutström (2008) evaluate the strengths and weaknesses of alternative elicitation procedures for risk attitudes.

[4]The four sets of prizes were as follows, with the two prizes for lottery A listed first and the two prizes for lottery B listed next: (A1: 2,000 kroner, 1,600 kroner; B1: 3,850 kroner, 100 kroner), (A2: 2,250 kroner, 1,500 kroner; B2: 4,000 kroner, 500 kroner), (A3: 2,000 kroner, 1,750 kroner; B3: 4,000 kroner, 150 kroner), and (A4: 2,500 kroner, 1,000 kroner; B4: 4,500 kroner, 50 kroner). At the time of the experiments, the exchange rate was approximately 6.55 kroner per U.S. dollar, so these prizes range from approximately $7.65 to $687.

[5]There is considerable behavioral evidence that rewarding subjects by selecting one task at random for payment does not distort choices, even though it does make the overall experiment a compound lottery. See Harrison, Lau, and Rutström (2007, fn. 16) for evidence on this issue for the risk aversion instrument we used here, and Harrison and Rutström (2008, section 2.6) for similar evidence in comparable lottery choice tasks.

We take each of the binary choices of the subject as the data and estimate the parameters of a latent utility function that explains those choices using an appropriate error structure to account for the panel nature of the data.[6] The data set consists of observations from 253 subjects, with 7,928 risk aversion choices.[7] Once the utility function is defined, for a candidate value of the parameters of that function, we can construct the expected utility of the two gambles, and then use a linking function to infer the likelihood of the observed choice.

Time Preferences: Measuring Individual Discount Rates

Individual discount rates (IDRs) were elicited by an experimental design that was introduced in Coller and Williams (1999) and expanded in Harrison, Lau, and Williams (2002). Each subject in Harrison et al. (2005) was presented with six discount rate tasks with six different time horizons: 1, 4, 6, 12, 18, and 24 months. In each task subjects were provided two future income options rather than one "instant income" option and one future income option. The early income option was 3,000 kroner and delayed by 1 month in all tasks. For example, they were offered 3,000 kroner in 1 month and 3,000 kroner + x kroner in 7 months, so that we interpret the revealed discount rate as applying to a time horizon of 6 months. This avoids the potential problem of the subject facing extra risk or transactions costs with the future income option, as compared to the "instant" income option.[8]

Each subject responded to all six discount rate tasks, and one task and row were chosen at random for payment. Future payments to subjects were guaranteed by the

[6]The statistical specification allows for the possibility of correlation between responses by the same subject. The use of clustering to allow for "panel effects" from unobserved individual effects is common in the statistical survey literature. Clustering commonly arises in national field surveys from the fact that physically proximate households are often sampled to save time and money, but it can also arise from more homely sampling procedures. For example, Williams (2000, p. 645) notes that it could arise from dental studies that "collect data on each tooth surface for each of several teeth from a set of patients" or "repeated measurements or recurrent events observed on the same person." The procedures for allowing for clustering allow heteroskedasticity between and within clusters, as well as autocorrelation within clusters. They are closely related to the "generalized estimating equations" approach to panel estimation in epidemiology (see Liang and Zeger, 1986), and generalize the "robust standard errors" approach popular in econometrics (see Rogers, 1993). Wooldridge (2003) reviews some issues in the use of clustering for panel effects, in particular noting that significant inferential problems may arise with small numbers of panels.

[7]Some subjects received a different number of choices than others. For example, 116 subjects received a "symmetric" risk aversion task involving 40 choices ($116 \times 40 = 4{,}640$ choices) and the remaining 137 subjects received an "asymmetric" risk aversion task involving 24 choices ($137 \times 24 = 3{,}288$ choices).

[8]These transactions costs are discussed in Coller and Williams (1999), and they include simple things such as remembering to pick up the delayed payment as well as more complex things such as the credibility of the money actually being paid in the future. The payment protocol in the experiment was intended to make sure that the credibility of receiving the money in the future was high.

Danish Ministry of Economic and Business Affairs, and made by automatic transfer from the Ministry's bank account to the subject's bank account. This payment procedure is similar to a postdated check, and automatic transfers between bank accounts are a common procedure in Denmark. Finally, each subject was given a 10 percent chance to receive actual payment. Thus, each subject faced a 10 percent chance of receiving payment in the risk preference task as well as a 10 percent chance in the time preference task.

Our estimation strategy is the same as for the lottery task. We take each of the binary choices of the subject as data, and estimate the parameters with an error structure that recognizes the panel nature of the data. The data set consists of 15,180 discount rate choices.

IDENTIFYING RISK AND TIME PREFERENCES

Estimation of Risk Attitudes

We begin with expected utility theory (EUT) as a model for the choices over risky options and let the utility function be the constant relative risk aversion (CRRA) specification

$$U(M) = \frac{(\omega + \mathrm{M})^{(1-r)}}{(1-r)} \tag{1}$$

for $r \neq 1$, where r is the CRRA coefficient and ω is background consumption. With this functional form, $r = 0$ denotes risk-neutral behavior, $r > 0$ denotes risk aversion, and $r < 0$ denotes risk-loving behavior.[9]

We can write out the likelihood function for the choices that the subjects made and estimate the risk parameter r. Probabilities for each outcome M_j, $p_j(M_j)$, are those that are induced by the experimenter, so expected utility is simply the probability weighted utility of each outcome in each lottery. Since there were two outcomes in each lottery, the EU for lottery i is

$$\mathrm{EU}_i = \sum_{j=1,\, n} [p_j(M_j) \times U(\omega + M_j)], \tag{2}$$

where $n = 2$.

[9]There is evidence from the lab and field that subjects are risk averse over stakes ranging between pennies and several hundred dollars. Holt and Laury (2002, 2005) produce the most widely cited evidence from the lab, and they show that subjects are moderately averse to risk. Harrison, Lau, and Rutström (2007) find comparable results using data from the Danish field experiments that we also apply in our analysis. The literature offers some evidence of lower estimates of relative risk aversion when the stakes in the experimental task are reduced significantly, which may cause one to question our use of the restrictive CRRA function. However, Harrison, Lau, and Rutström find that CRRA holds locally over the domain of stakes in the Danish experiments, and we therefore adopt this popular specification.

TABLE 1
Estimates of Risk Preferences Assuming EUT

	Estimate	Standard Error	95% Confidence Interval	
Constant relative risk aversion				
Average	0.73	0.045	0.64	0.81
Men	0.69	0.051	0.59	0.79
Women	0.76	0.039	0.69	0.84
Younger than 30 years of age	0.82	0.058	0.71	0.93
Between 30 and 40 years of age	0.76	0.078	0.60	0.91
Between 40 and 50 years of age	0.88	0.057	0.77	0.99
Between 50 and 60 years of age	0.85	0.070	0.71	0.99
Older than 60 years of age	0.89	0.057	0.78	1.00
Single	0.74	0.042	0.66	0.83
Lives with spouse or partner	0.72	0.050	0.62	0.81

Conditional on EUT and CRRA specifications being true, the likelihood of the risk aversion responses depends on the estimates of r and the observed choices. We follow Andersen et al. (2008a) and assume that income from the risk aversion and discount rate tasks is integrated with daily background consumption, which was equal to 118 kroner for the average Dane in 2003. We use this value of ω in our estimations.

Table 1 displays the results from maximum likelihood estimation of elicited risk attitudes.[10] The results show that the average Dane is risk averse with a CRRA coefficient of 0.73 and a standard error of 0.045. This coefficient is significantly different from 0 and marginally higher than the estimate of 0.67, which is reported in Harrison, Lau, and Rutström (2007) for the same data set but with background consumption $\omega = 0$.

We also report total effects of key demographic variables; that is, we condition the CRRA coefficient on one demographic characteristic at a time. The coefficients from the maximum likelihood estimations are displayed in Table 1 and show some variation in risk attitudes across the demographic characteristics. Women are more risk averse than men. The CRRA coefficient is 0.76 for women and 0.69 for men, and the difference of 0.07 is statistically significant with a p-value of 0.016. We find some variation across age groups, but there is no general tendency for younger age groups to be more or less risk averse than older age groups. Finally, we do not observe significant differences in risk attitudes between singles and those who live with a spouse or partner.[11]

[10]We follow Holt and Laury (2002) and Andersen et al. (2008a) and use the error specification originally due to Luce (1959) in our estimation of risk attitudes and discount rates.

[11]Harrison, Lau, and Rutström (2007) find evidence of sample selection into the experiment, and the mean estimate of relative risk aversion is reduced by this correction. However, the marginal effects of individual characteristics are similar across specifications with and without correction for sample selection.

Rank-Dependent Utility Theory

One route of departure from EUT has been to allow preferences to depend on the rank of the final outcome through probability weighting. The idea that one could use nonlinear transformations of the probabilities of a lottery when weighting outcomes, instead of nonlinear transformations of the outcome into utility, is most sharply presented by Yaari (1987). To illustrate the point, he assumes a linear utility function, in effect ruling out any risk aversion or risk seeking from the shape of the utility function. Instead, concave (convex) probability weighting functions imply risk seeking (risk aversion). It is possible for a decision maker to have a probability weighting function with both concave and convex components, and the conventional wisdom is that the function is concave for smaller probabilities and convex for larger probabilities.

Quiggin (1982) formally presents the general case of rank-dependent preferences for choice over lotteries in which one allowed for subjective probability weighting and nonlinear utility functions. This model has become known as rank-dependent utility (RDU). The Yaari (1987) model can be seen as an important special case and can be called the rank-dependent expected value model.

Formally, to calculate decision weights under RDU one replaces expected utility in Equation (2) with

$$\mathrm{RDU}_i = \sum_{j=1,\, n} [w_j \times u_j], \tag{3}$$

where

$$w_j = \omega(p_j + \cdots + p_n) - \omega(p_{j+1} + \cdots + p_n) \tag{4}$$

for $j = 1, \ldots, n - 1$, and $w_j = \omega(p_j)$ for $j = n$. The subscript j indicates outcomes ranked from worst to best, and where $\omega(p)$ is some probability weighting function.

Picking the right probability weighting function is obviously important for the RDU specification. A weighting function proposed by Tversky and Kahneman (1992) has been widely used. It is assumed to have well-behaved endpoints with $\omega(0) = 0$ and $\omega(1) = 1$ and is given by

$$\omega(p) = \frac{p^\gamma}{[p^\gamma + (1-p)^\gamma]^{1/\gamma}} \tag{5}$$

for $0 < p < 1$. The normal assumption, backed by a substantial amount of evidence reviewed by Gonzalez and Wu (1999), is that $0 < \gamma < 1$. This gives the weighting function an "inverse S-shape," characterized by a concave section signifying the overweighting of small probabilities up to a crossover point where $\omega(p) = p$, beyond which there is a convex section signifying underweighting. If $\gamma > 1$ the function takes the less conventional "S-shape," with convexity for smaller probabilities and concavity for larger probabilities. Under RDU, the probability associated with an outcome does not directly inform one about the decision weight of that outcome, and

TABLE 2
Estimates of Risk Preferences Assuming RDU

	CRRA		Probability Weighting (γ)	
	Estimate	Standard Error	Estimate	Standard Error
Average	0.41	0.039	0.68	0.028
Men	0.40	0.044	0.71	0.049
Women	0.44	0.066	0.67	0.040
Younger than 30 years of age	0.36	0.036	0.54	0.033
Between 30 and 40 years of age	0.36	0.038	0.61	0.053
Between 40 and 50 years of age	0.40	0.130	0.71	0.072
Between 50 and 60 years of age	0.51	0.064	0.80	0.084
Older than 60 years of age	0.22	0.094	0.62	0.053
Single	0.40	0.071	0.61	0.039
Lives with spouse or partner	0.41	0.040	0.70	0.032

the transformation of probabilities into decision weights depends on the parameters in the probability weighting function and the underlying probability distribution of outcomes.

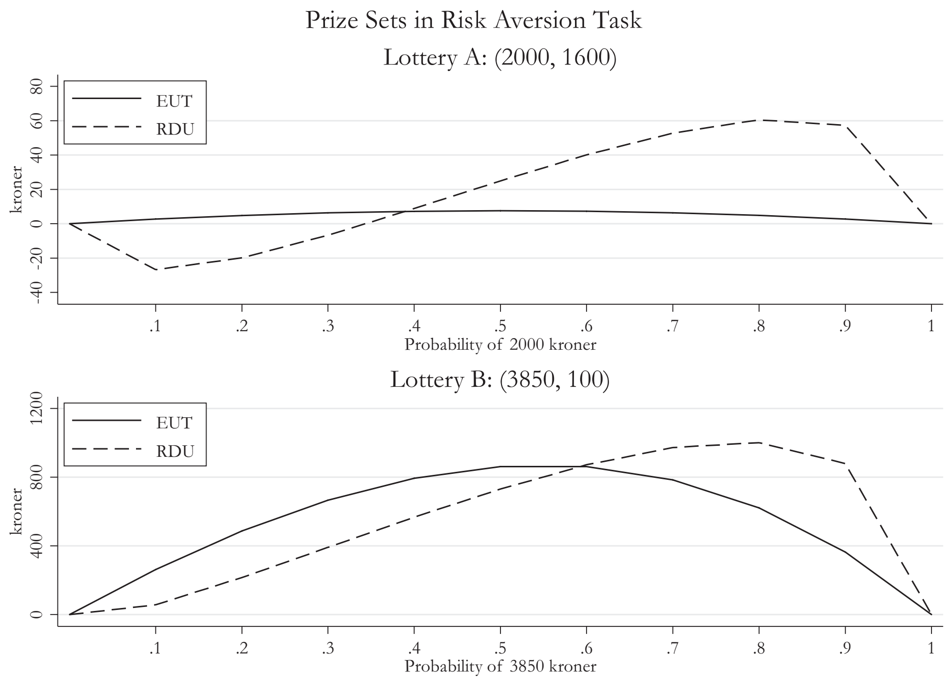
We again assume the CRRA functional form for utility. The parameter r determines the concavity of the utility function but is no longer the sole determinant of risk attitudes since probabilities are also transformed. The remainder of the econometric specification is the same as for the EUT model.

The effects of allowing for probability weighting are displayed in Table 2, and we find some evidence of probability weighting. The mean estimate of γ for the entire sample is 0.68 with a standard error of 0.028. The hypothesis that $\gamma = 1$, that there is no probability weighting, has a p-value of < 0.001 using a Wald test. The estimate of the curvature of the utility function, given by the CRRA coefficient, is smaller than the estimate of that parameter under EUT in the comparable specification. The effect of allowing for probability weighting is therefore to reduce estimates of the curvature of the utility function; we should be careful here not to conceptually associate curvature of the utility function with risk aversion.

The results in Table 2 show some variation in probability weighting across the demographic characteristics. The γ-parameter is < 1 for all demographic characteristics, and we can reject the hypothesis of no probability weighting at conventional statistical significance levels for each demographic variable. We also find more variation in the CRRA coefficients compared to the EUT model. There is no longer a significant difference in risk attitudes between men and women measured by the curvature of the utility function. However, we now find that people older than 60 years of age are significantly less risk averse than people in all other age groups.

We can illustrate the effect of probability weighting on the estimated risk premium for the lotteries that were presented to subjects in the experiment. The upper panel in Figure 1 displays the estimated risk premium under EUT and RDU for the lottery that

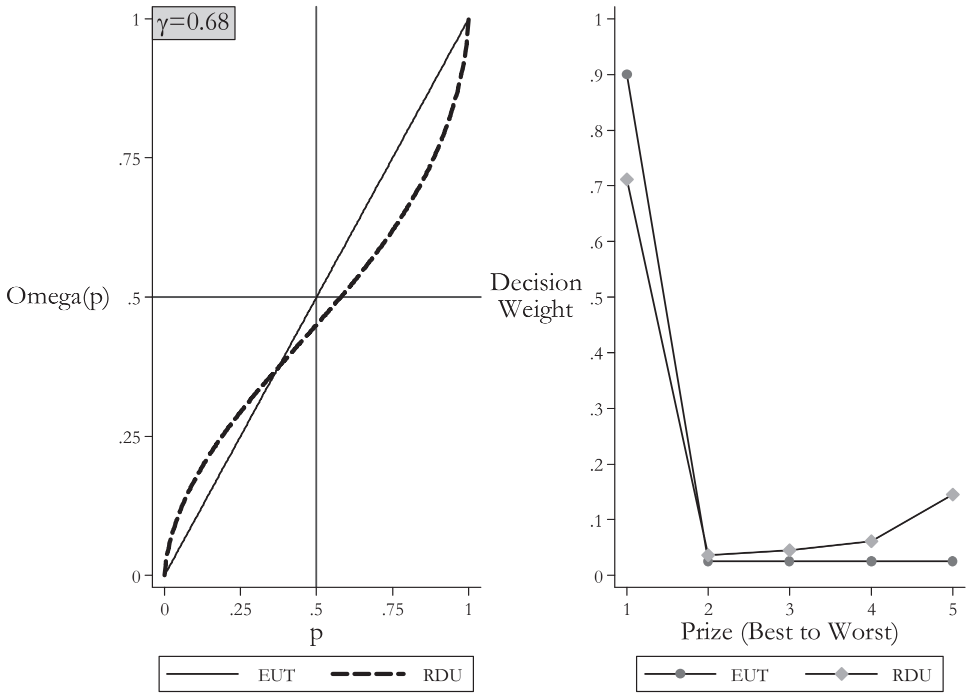
FIGURE 1
Estimated Risk Premium Under EUT and RDU



pays either 2,000 or 1,600 kroner. The solid line is based on EUT, and the dashed line is based on RDU. Given the estimated coefficients in Tables 1 and 2, we find that the risk premium is positive under EUT and follows an inverse U-shape when the probability of receiving the high amount increases from 0 to 1. However, the estimated risk premium under RDU is smaller, and indeed negative, when the probability of receiving the high amount is less than 0.4, and higher when the probability of receiving the high amount is higher than 0.4. The lower panel in Figure 1 displays the estimated risk premium under EUT and RDU for the lottery that pays either 3,850 or 100 kroner, and we find similar results although the crossover point between the two curves now appears when the probability of receiving the high amount is 0.6. Hence, we see that the estimated risk premium is higher under RDU than EUT when the probability of receiving the best outcome is relatively high.

Figure 2 displays the probability weighting function and decision weights for a lottery with five outcomes and a value of $\gamma = 0.68$. The underlying probability distribution in this example is unimodal and asymmetric with $p = 0.90$ for the best outcome and $p = 0.025$ for each of the four other outcomes. The rank-dependent specification assigns a weight of 76.8 percent to the best outcome, 3.5 percent to the second-best outcome, 4.1 percent to the third-best outcome, 5.3 percent to the fourth-best outcome, and a weight 10.3 percent to the worst outcome. Hence, we see a substantial reduction in the decision weight for the best outcome and higher decision weights for all other

FIGURE 2
Decision Weights Under EUT and RDU



outcomes compared to the EUT specification. In particular, there is a significant increase from 2.5 to 10.3 percent for the worst outcome.[12] The probability distribution in this example resembles the distributions of insurance claims in Figures 3–5 for the three insurance products that we consider, and the biases in the decision weights under RDU compared to EUT turn out to have significant effects on the estimated willingness to pay for the insurance products.

Estimation of Discount Rates

Consider next the joint estimation of risk and time preferences. Our statistical specification relies on a special case of the model in Andersen et al. (2008a), which is based on the dual self-representation of latent risk and time preferences by Fudenberg and Levine (2006). We assume that income earned from the risk and the discount rate tasks is integrated with the same level of daily background consumption.

[12] A uniform probability distribution with $p = 0.2$ for each of the five outcomes and $\gamma = 0.68$ would give the following decision weights under RDU, ranked from best to worst outcome: 0.26, 0.13, 0.12, 0.15, and 0.34. Hence, this distribution overweights the best and worst outcomes and underweights intermediate outcomes. This is different from the distribution of decision weights in Figure 2, which underweights the best outcome and overweights all other outcomes.

Specifically, if we assume that EUT holds for the choices over risky alternatives and that discounting is exponential then the subject is indifferent between two income options M_t and $M_{t+\tau}$ if and only if

$$U(\omega + M_t) + \left(\frac{1}{(1+\delta)^{\tau}}\right)U(\omega) = U(\omega) + \left(\frac{1}{(1+\delta)^{\tau}}\right)U(\omega + M_{t+\tau}), \tag{6}$$

where $U(\omega + M_t)$ is the utility of monetary outcome M_t for delivery at time t plus some measure of background consumption ω, δ is the discount rate, τ is the horizon for delivery of the later monetary outcome at time $t + \tau$, and the utility function U is separable and stationary over time.[13] The left-hand side of Equation (1) is the sum of the discounted utilities of receiving the monetary outcome M_t at time t (in addition to background consumption) and receiving nothing extra at time $t + \tau$, and the right-hand side is the sum of the discounted utilities of receiving nothing over background consumption at time t and the outcome $M_{t+\tau}$ (plus background consumption) at time $t + \tau$. Thus, (6) is an indifference condition and δ is the discount rate that equalizes the present value of the utility of the two monetary outcomes M_t and $M_{t+\tau}$, after integration with an appropriate level of background consumption ω.

We can write out the likelihood function for the choices that our subjects made and estimate the risk parameter r and the discount rate δ. Instead of specifying the expected utility of option A and B, Equation (2) is replaced by the discounted utility of each of the two options, conditional on some assumed discount rate.

Table 3 displays the results from joint maximum likelihood estimation of elicited discount rates and risk attitudes. The results show that the average Dane has an estimated annual discount rate of 10.1 percent with a standard error of 0.85 percent. This estimate is similar to the reported value in Andersen et al. (2008a). We find a small and insignificant difference in discount rates between men and women. Men have a discount rate of 10.3 percent and the estimated coefficient for women is 9.9 percent. The results indicate a systematic variation in discount rates across age groups, and we find that younger people have lower discount rates than older people. Discount rates vary between 9.0 percent for people younger than 30 years of age to 12.1 percent for those older than 60 years of age. Finally, there is some variation in discount rates between singles and those living with a partner or spouse.

The mean estimate of the CRRA coefficient is the same as before, but we find less variation in the estimated coefficients across demographic variables compared to the values reported in Table 1. For example, the difference in risk aversion between men and women is smaller and no longer statistically significant.

[13] Andersen et al. (2008b) use panel data from these Danish experiments and find some variation in risk attitudes over time, but there is no general tendency for risk aversion to increase or decrease over the 17 months time span that they consider.

TABLE 3
Estimates of Time Preferences Assuming Exponential Discounting

	Estimate	Standard Error	95% Confidence Interval	
Average	0.101	0.0085	0.084	0.117
Men	0.103	0.0105	0.083	0.124
Women	0.099	0.0088	0.082	0.116
Younger than 30 years of age	0.090	0.0126	0.065	0.115
Between 30 and 40 years of age	0.092	0.0127	0.067	0.117
Between 40 and 50 years of age	0.099	0.0116	0.076	0.121
Between 50 and 60 years of age	0.102	0.0124	0.078	0.126
Older than 60 years of age	0.121	0.0160	0.089	0.152
Single	0.115	0.0120	0.091	0.138
Lives with spouse or partner	0.097	0.0091	0.079	0.114

ESTIMATING WILLINGNESS TO PAY

We assume that households maximize expected intertemporal utility subject to an intertemporal budget constraint with several possible states of nature, where all uncertainty is realized in the initial period and any loss incurred by an accident is subtracted from initial wealth. Since potential insurance claims may be substantial in comparison to annual income, it is appropriate to allow for consumption smoothing over time and thereby cushion the impact of an accident on consumption in the short term.

Model

We first present the model without uncertainty to illustrate the intertemporal optimization problem over a finite time period T, and then introduce uncertainty to estimate the willingness to pay for each insurance type.

The intertemporal utility function at time $t = 0$ of the representative household is given by

$$U = \sum_{\{t=0,\ldots T-1\}} (1+\delta)^{-t} u(c_t), \tag{7}$$

where c_t is consumption in period t. The instantaneous utility function

$$u(c_t) = \frac{(c_t)^{(1-r)}}{(1-r)} \tag{8}$$

is stationary and similar to the CRRA specification in (1). The dynamic budget constraint is

$$W_{t+1} = (1+i)(W_t + y_t - c_t), \tag{9}$$

where i is the (constant) real interest rate, W_t is financial wealth in period t, and y_t is income in period t. Financial wealth in the terminal period cannot be negative and is specified as a fraction α of initial wealth $W_T = \alpha W_0$, with $\alpha \geq 0$.[14] The intertemporal budget constraint is derived from the dynamic budget constraint (9) and the terminal constraint, and is written as

$$\sum_{\{t=0,\ldots T-1\}} (1+i)^{-t} c_t = \sum_{\{t=0,\ldots T-1\}} (1+i)^{-t} y_t + (1 - \alpha(1+i)^{-T}) W_0. \tag{10}$$

This constraint implies that the net present value of intertemporal consumption is equal to the net present value of intertemporal income plus initial financial wealth minus the net present value of financial wealth in the final period.

Maximizing intertemporal utility subject to the intertemporal budget constraint gives the Euler equation, which specifies the optimal consumption profile over the finite time horizon

$$c_{t+1} = \left(\frac{(1+i)}{(1+\delta)}\right)^{1/r} c_t, \tag{11}$$

where $1/r$ is the intertemporal elasticity of substitution. We can then derive consumption in period t as a function of consumption in the initial period and insert the expression into the intertemporal budget constraint to find the optimal level of consumption in the initial period

$$c_0 = M \cdot \left(\sum_{\{t=1,\ldots T-1\}} (1+i)^{-t} y_t + (1 - \alpha(1+i)^{-T}) W_0 \right) \tag{12}$$

with

$$M = \frac{1}{\sum_{\{t=1,\ldots T-1\}} (1+i)^{-t} ((1+i)/(1+\delta))^{t/r}}. \tag{13}$$

Hence, consumption in the initial period is determined by a multiplier times the present value of lifetime income minus net savings from the initial to the final period. The optimal level of consumption over time (c_t^*) is then derived by inserting Equation (12) into Equation (11). The multiplier in Equation (13) is a function of the real interest rate and the IDR. We see that a higher discount rate puts more weight on

[14]Strictly speaking, α should be endogenous in the model because households decide how much wealth to hold in period T. However, one would need a bequest or precautionary savings motive to obtain a positive level of wealth in the final period. Adding these motives would make it more complicated to estimate the willingness to pay. We vary the value of α in the sensitivity analysis and find that the willingness to pay is robust to variations in the value of this parameter.

present consumption by increasing the multiplier in Equation (13), and less weight on future consumption by reducing the growth rate in Equation (11). A higher interest rate reduces the present value of lifetime income and has a negative income effect on consumption in the present and in the future. However, a higher interest rate reduces the price of future consumption relative to present consumption, and the substitution effect dominates the income effect if the intertemporal elasticity of consumption ($1/r$) is < 1, that is, if $r < 1$.

We now add uncertainty to the decision problem in order to calculate willingness to pay for insurance under assumptions of symmetric information and no default risk for the insurer. We divide the claims data for each insurance product into five categories and assume that the representative household can end up in five possible states ($s = 1, \ldots, 5$) depending on the size of the claim. The five claims categories are presented in the "Insurance Data" section for each insurance product.[15] Expected inter-temporal utility is then given by

$$\mathrm{EU} = \sum_{\{s=1,\ldots,5\}} p_s \sum_{\{t=0,\ldots,T-\}} (1+\delta)^{-t} u(c^*_{s,t}), \tag{14}$$

where p_s is the probability of ending up in state s, and $c^*_{s,t}$ is the optimal level of consumption in state s at time t. The decision weights are revised under RDU theory, which allows for subjective probability weighting.

We assume that all uncertainty is realized in the initial period, and any loss incurred by an accident is subtracted from initial wealth

$$W_{s,0} = W_0 - L_s, \tag{15}$$

where $W_{s,0}$ is wealth in the initial period after realization of loss L in state s.[16] The losses refer to the claims categories in the insurance data. Hence, the optimal level of consumption in the initial period for each state s can be written as

$$c^*_{s,0} = M \cdot \left(\sum_{\{t=1,\ldots T-1\}} (1+i)^{-t} y_t + (1 - \alpha(1+i)^{-T})(W_0 - L_s) \right), \tag{12$'$}$$

and the optimal level of consumption over time ($c^*_{s,t}$) is then derived by inserting Equation (12′) into Equation (11).

[15]The five claims categories are similar for each insurance product, but the distribution of claims for each insurance product varies across the different types of households that we consider in our analysis. We assume that all households buy the same insurance product, and differences in the willingness to pay are due to different household characteristics and distributions of claims.

[16]We assume here that the insurance products carry no excess. One can easily extend the analysis and reduce the claims by a constant excess, which of course will reduce the willingness to pay for insurance. The claims data from Tryg are net of excess.

The willingness to pay for insurance is defined as the certain reduction, P, in initial wealth that makes the household indifferent between paying this insurance premium and entering a lottery with five possible outcomes. The estimated willingness to pay is based on annual claims and should thus be considered as the annual premium that the household is willing to pay for insurance.

To estimate the willingness to pay for insurance we consider the optimal level of expected intertemporal utility with and without insurance

$$U = \sum_{\{t=0,\ldots T-1\}} (1+\delta)^{-t} u(c_t^*) = \mathrm{EU}, \tag{16}$$

where c_t^* is the optimal level of consumption at time t *with* insurance, and EU is expected utility *without* insurance and given by Equation (14). Inserting the Euler Equation (11) into (16) gives the following expression

$$c_0^* = (M \cdot \mathrm{EU}(1-r))^{1/(1-r)}. \tag{17}$$

The optimal level of consumption in the initial period with insurance can also be written as

$$c_0^* = M \cdot \left(\sum_{\{t=1,\ldots T-1\}} (1+i)^{-t} (y_t + (1 - \alpha(1+i)^{-T})(W_0 - P) \right). \tag{12''}$$

Finally, we can derive the maximum insurance premium P that the household is willing to pay by inserting Equation (12″) into (17), assuming the premium is paid in the initial period

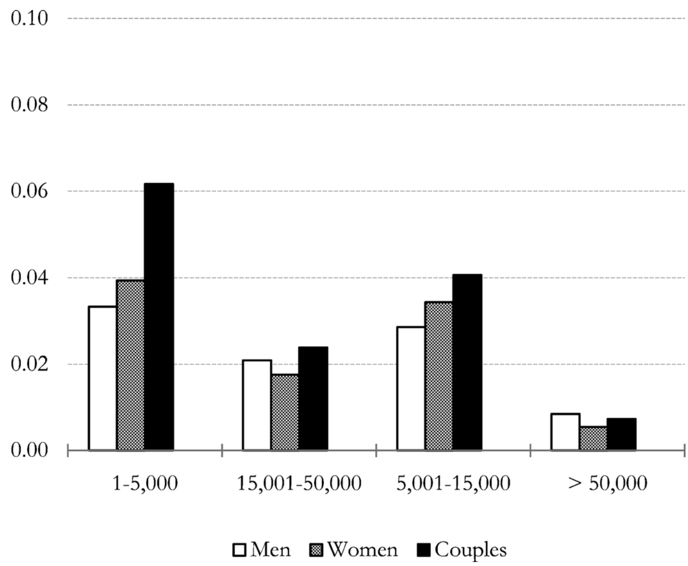
$$P = \sum_{\{t=1,\ldots T-1\}} (1+i)^{-t} y_t + (1 - \alpha(1+i)^{-T}) W_0 - M^{r/(1-r)} (\mathrm{EU}(1-r))^{1/(1-r)}. \tag{18}$$

We thus need information on insurance claims, financial wealth, annual income, market interest rates, risk attitudes, and discount rates. We have access to this information in Denmark, although we cannot map the information on risk attitudes and discount rates to the claims data from Tryg and income and wealth data from Statistics Denmark. Hence, we assume that the sample in the field experiment is representative of the customers at Tryg.

INSURANCE DATA

The insurance data set is kindly provided by the largest Danish general insurance company, Tryg, with a market share slightly above 20 percent, and our use of the data has been approved by the Danish Financial Supervisory Authority and the Danish Data Protection Agency. The data set contains 1,004,032 observations from customers who bought an auto, home, or house insurance policy in 2004. We have information on insurance claims data and use personal ID numbers to map this information with

FIGURE 3
Distribution of Auto Insurance Claims by Household Type (Danish Kroner)



data from registers at Statistics Denmark to obtain information on annual income and financial wealth at the level of the individual and the household. The insurance policies cover the entire household, which we consider as the unit of analysis in our estimations of the willingness to pay for insurance.

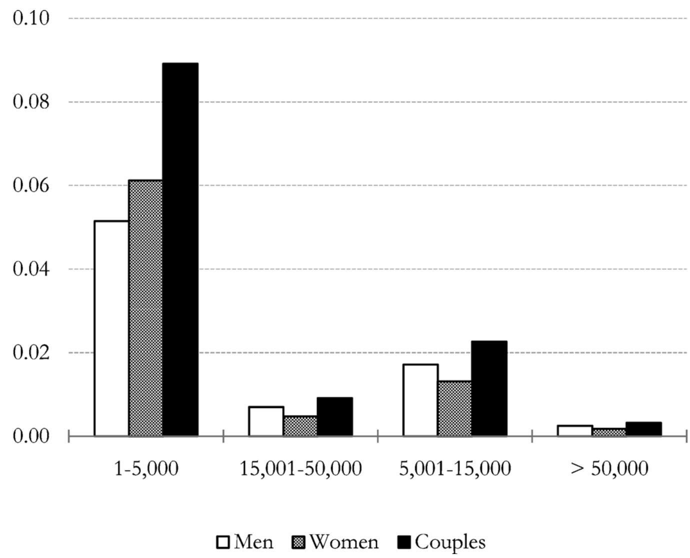
For each type of insurance policy we divide the households into five claims categories: (1) those with no insurance claim, (2) those with an insurance claim of 1–5,000 kroner, (3) those with a claim of 5,001–15,000 kroner, (4) those with a claim of 15,001–50,000 kroner, and finally (5) customers with a claim of 50,001 kroner or more. This gives us a discrete distribution of claims for each type of insurance.[17]

Figure 3 displays the distribution of auto insurance claims for single men, single women, and couples.[18] We have 326,426 observations on auto insurance claims in 2004, and omit the no-claims category in the figure. The probability of filing an auto

[17]The premium for most insurance policies in Denmark is paid on a yearly basis. In the few cases where households have filed more than one insurance claim in 2004, these claims have been pooled into a single total claim to reflect the total repayment over the year. In this way the computed willingness to pay is comparable to the insurance premiums actually paid in 2004.

[18]Individual risk and time preferences are estimated for one demographic characteristic at a time and mapped to the insurance data using equal weights for each characteristic. For example, in the case of single men between 30 and 40 years of age, the mapping is 1/3 times the estimate for males plus 1/3 times the estimate for the age group between 30 and 40 years of age plus 1/3 times the estimate for singles. In the case of couples, the first term is replaced by 1/6 times the estimate for men and 1/6 times the estimate for women (assuming heterosexual relationships).

FIGURE 4
Distribution of Home Insurance Claims by Household Type (Danish Kroner)



insurance claim in 2004 was 9 percent for single men, 10 percent for single women, and 13 percent for couples. We observe that couples have a higher risk of filing an auto insurance claim than single men and women, respectively. This is presumably because many couples own one car only and drive more combined compared to single men and women. We also find that single men have a marginally higher probability of filing an auto insurance claim of more than 50,000 kroner compared to single women and couples.

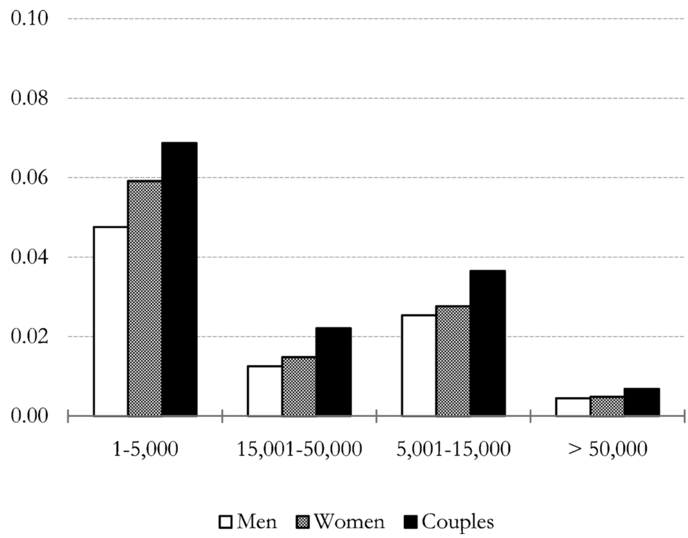
The data set contains 444,748 observations on home insurance, and the distribution of claims that were filed in 2004 is displayed in Figure 4. Most insurance claims are relatively small and fall in the interval of 1–5,000 kroner, and couples are more likely to file a home insurance claim in that interval compared to single men and women. The probability of filing a home insurance claim was 8 percent for both single men and women and 12 percent for couples.

Finally, we have 232,858 observations on house insurance claims in 2004. Figure 5 shows that couples are more likely to file a house insurance claim than single men and women, like the two other types of insurance. The probability of filing a claim is marginally lower for single men and women compared to couples in each claims category, which is the general pattern we see across all insurance types and claims categories. The probability of filing a house insurance claim in 2004 was 9 percent for single men, 11 percent for single women, and 13 percent for couples.

WTP FOR AUTO, HOME, AND HOUSE INSURANCE

The model is calibrated to the claims data from the customer database at Tryg and information on annual income after tax and private financial wealth from Statistics

FIGURE 5
Distribution of House Insurance Claims by Household Type (Danish Kroner)



Denmark.[19] Households are divided into five age categories, and we generally observe an inverse U-shape of income after tax and an increasing level of financial wealth as the customers get older.[20] We calculate how much each household is willing to pay for insurance using estimates of relative risk aversion and discount rates from the Danish field experiments. The insurance claims may be substantial relative to annual income, and we assume that households have a 10-year planning horizon and choose the optimal consumption profile over this timespan. Annual income is constant in the estimations and net savings over the 10-year time period is set to zero, and we use a market interest rate of 4 percent in the baseline calculations.[21]

Auto Insurance

Panel A in Table 4 displays the average annual auto insurance claims for men, women, and couples across different age groups. There are substantial differences in

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[19]We use GAMS to estimate the WTP for insurance products. The programs and aggregate data are available from the authors on request. However, due to confidentiality issues we are not permitted to pass on insurance data at the household level to third parties.

[20]Age groups are assigned to the oldest member of the household. Tables A1 and A2 in the Appendix (which is available from the authors upon request) shows the distribution of after-tax income and financial wealth for those men, women, and couples who purchased auto, home, and auto insurance at Tryg in 2004.

[21]These assumptions imply that the present discounted value of consumption is equal to the present discounted value of income over the 10-year time period, and the consumption profile is declining over time because $i < \delta$. We do not find significant differences in the estimated willingness to pay when the market interest rate is increased to 10 percent.

Table 4
Auto Insurance Claims and Willingness to Pay (Danish Kroner)

	Men	Women	Couples
Panel A: Average Insurance Claims			
Younger than 30 years of age	3,197	1,550	3,159
Between 30 and 40 years of age	2,506	2,226	2,226
Between 40 and 50 years of age	1,931	2,204	2,722
Between 50 and 60 years of age	1,862	1,360	2,240
Older than 60 years of age	1,153	1,137	1,637
Panel B: Willingness to Pay Assuming EUT			
Younger than 30 years of age	3,307	1,586	3,212
Between 30 and 40 years of age	2,548	2,281	2,242
Between 40 and 50 years of age	1,957	2,239	2,743
Between 50 and 60 years of age	1,891	1,372	2,254
Older than 60 years of age	1,163	1,145	1,650
Panel C: Willingness to Pay Assuming RDU			
Younger than 30 years of age	14,766 (1,597)	9,001 (983)	17,490 (1,728)
Between 30 and 40 years of age	10,394 (1,330)	11,891 (1,579)	10,807 (1,297)
Between 40 and 50 years of age	7,486 (1,185)	8,641 (1,264)	10,855 (1,509)
Between 50 and 60 years of age	6,270 (1,087)	4,601 (745)	7,900 (1,232)
Older than 60 years of age	5,108 (706)	5,257 (668)	8,762 (1,140)
Panel D: Willingness to Pay Assuming RDU and Two Claims Categories			
Younger than 30 years of age	8,795 (655)	4,900 (357)	8,644 (529)
Between 30 and 40 years of age	5,836 (463)	5,553 (420)	5,005 (326)
Between 40 and 50 years of age	4,377 (433)	4,796 (416)	5,408 (398)
Between 50 and 60 years of age	3,778 (395)	2,754 (264)	4,234 (351)
Older than 60 years of age	2,949 (261)	2,931 (233)	4,064 (296)

these insurance claims across households. Single men younger than 30 years of age have an average auto insurance claim of 3,197 kroner per annum, which is twice as high as the average insurance claim for single women in the same age group, and marginally higher than the average insurance claim for couples. Average annual insurance claims fall with age and there is only a marginal difference in insurance claims between single men and women who are older than 60 years of age (1,153 kroner for men and 1,137 kroner for women).

Panel B shows the estimated annual willingness to pay for auto insurance assuming EUT. Since there is some uncertainty about the estimates of risk attitudes and discount rates, there is some uncertainty about the estimated willingness to pay. We use a randomized factorial design in our sensitivity analysis and undertake 10,000 perturbations (Harrison and Vinod, 1992). Each simulation involves a random draw from independent normal distributions of the CRRA parameter and the IDR for each type of household. We report the mean values and standard deviations of these simulations, and the results show that the willingness to pay is marginally higher than the average insurance claims for the various household types. For example, the willingness to pay for men younger than 30 years of age is 3,307 kroner compared to the average insurance claim of 3,197 kroner, which gives a difference of 110 kroner. The standard deviation of the estimated WTP is small and < 5 kroner across all types of households. Hence, there is little variation in the estimated WTP when we consider the uncertainty of the elicited risk attitudes and discount rates and assume that the households behave according to EUT.

This pattern is different when we look at the willingness to pay under RDU. Panel C in Table 4 shows that the willingness to pay for auto insurance increases significantly when we allow for probability weighting and adjust the weights for each category of claims. For example, the mean estimate of the willingness to pay for men younger than 30 years of age is 14,766 kroner with the rank-dependent specification, which is significantly higher than the mean estimate of 3,303 kroner under EUT. We also observe that the standard deviation of the estimated WTP increases considerably and is 1,597 kroner for men younger than 30 years of age. These effects are similar for other types of households, and we find that the estimated WTP increases between 300 and 600 percent for the RDU specification compared to the EUT assumption.

Panel D shows the effect of probability weighting on the estimated WTP when we consider two claims categories and only distinguish between no insurance claims and positive claims. The estimated WTP under EUT does not change and is similar to the results in Panel B. However, the decision weights change under RDU, and we generally observe a smaller effect on estimated WTP compared to the estimations in Panel C with five claims categories. The estimated WTP under RDU and two claims categories are still substantially higher than the estimated WTP under EUT, but are approximately 50 percent lower compared to the estimates under RDU with five claims categories.

Home Insurance

We next present the results for the home insurance product. Table 5 shows that the average home insurance claims vary between 358 kroner for women older than 60 years of age to 1,257 kroner for couples younger than 30 years of age. These average claims are lower than those for auto insurance. This is not because the risk of filing a home insurance claim is lower than the risk of having a car accident, but the claims are generally lower for home insurance. The estimated WTP for home insurance is marginally higher than the average insurance claims for all types of household using the EUT specification, and we find again a significant increase in the estimated WTP for the rank-dependent specification compared to the EUT assumption. For example, the estimated WTP for home insurance is 3,186 kroner for women older than 60 years, which is nine times higher than the mean estimate of 352 kroner under the EUT assumption.

House Insurance

Finally, we present the results for house insurance. Table 6 shows the expected claims and WTP for this type of insurance. We find that the average claims vary between

TABLE 5
Home Insurance Claims and Willingness to Pay (Danish Kroner)

	Men	Women	Couples
Panel A: Average Insurance Claims			
Younger than 30 years of age	967	791	1,257
Between 30 and 40 years of age	929	883	1,223
Between 40 and 50 years of age	803	863	1,258
Between 50 and 60 years of age	537	744	1,027
Older than 60 years of age	358	344	676
Panel B: Willingness to Pay Assuming EUT			
Younger than 30 years of age	978	800	1,268
Between 30 and 40 years of age	939	891	1,229
Between 40 and 50 years of age	812	872	1,264
Between 50 and 60 years of age	542	754	1,033
Older than 60 years of age	363	352	683
Panel C: Willingness to Pay Assuming RDU			
Younger than 30 years of age	5,018 (624)	4,630 (544)	8,379 (977)
Between 30 and 40 years of age	4,831 (725)	4,879 (692)	6,839 (911)
Between 40 and 50 years of age	3,903 (728)	4,030 (694)	5,715 (891)
Between 50 and 60 years of age	2,202 (446)	3,391 (674)	4,474 (814)
Older than 60 years of age	2,742 (506)	3,186 (566)	5,578 (897)
Panel D: Willingness to Pay Assuming RDU and Two Claims Categories			
Younger than 30 years of age	2,224 (141)	1,847 (105)	2,809 (144)
Between 30 and 40 years of age	2,329 (199)	2,008 (139)	2,730 (176)
Between 40 and 50 years of age	1,893 (195)	1,719 (135)	2,383 (165)
Between 50 and 60 years of age	1,258 (155)	1,618 (169)	2,083 (189)
Older than 60 years of age	1,266 (146)	1,239 (128)	2,064 (179)

888 kroner for men older than 60 years of age and 2,680 kroner for couples between 30 and 40 years of age. Couples have higher claims than single men and women, and the likely reason is that they have larger homes than single men and women. The results show that the risk premium is small under the EUT specification and it increases significantly under the RDU specification.

Sensitivity Analysis

To examine how sensitive the estimates are to our choice of parameters, we also vary the planning horizon, the level of net savings over this horizon, and the market interest rate.[22] We find that the estimated WTP increases generally when the planning horizon is reduced. For example, the willingness to pay for auto insurance for men

[22]The estimates are displayed in Table A3 for the EUT model and Table A4 for the RDU model.

TABLE 6
House Insurance Claims and Willingness to Pay (Danish Kroner)

	Men	Women	Couples
Panel A: Average Insurance Claims			
Younger than 30 years of age	1,732	1,758	2,226
Between 30 and 40 years of age	2,518	1,997	2,680
Between 40 and 50 years of age	1,351	1,901	2,475
Between 50 and 60 years of age	1,298	1,916	2,101
Older than 60 years of age	888	1,235	2,169
Panel B: Willingness to Pay Assuming EUT			
Younger than 30 years of age	1,786	1,784	2,248
Between 30 and 40 years of age	2,582	2,033	2,704
Between 40 and 50 years of age	1,365	1,930	2,494
Between 50 and 60 years of age	1,311	1,941	2,115
Older than 60 years of age	895	1,250	2,193
Panel C: Willingness to Pay Assuming RDU			
Younger than 30 years of age	11,147 (1,485)	8,450 (829)	12,329 (1,247)
Between 30 and 40 years of age	12,387 (1,749)	10,221 (1,330)	13,444 (1,637)
Between 40 and 50 years of age	5,678 (958)	8,018 (1,234)	10,431 (1,502)
Between 50 and 60 years of age	4,461 (794)	6,712 (1,105)	7,827 (1,268)
Older than 60 years of age	4,404 (657)	6,537 (892)	12,146 (1,606)
Panel D: Willingness to Pay Assuming RDU and Two Claims Categories			
Younger than 30 years of age	4,675 (344)	4,939 (329)	5,492 (308)
Between 30 and 40 years of age	6,153 (512)	4,738 (342)	5,960 (383)
Between 40 and 50 years of age	3,035 (298)	3,942 (325)	5,075 (387)
Between 50 and 60 years of age	2,635 (276)	3,657 (325)	4,087 (351)
Older than 60 years of age	2,241 (196)	3,058 (234)	5,075 (349)

younger than 30 years of age increases from 3,303 to 5,539 kroner when the time horizon is reduced from 10 years to 1 year, using the EUT specification. The results are similar for the RDU specification when we reduce the time horizon. A shorter planning horizon reduces the present value of income, and the insurance claims will therefore have a greater relative impact on income. The greater variation in income leads to an increase in the estimated WTP for all three types of insurance.

There is no significant effect on the estimated WTP when financial wealth in the final period is equal to 0. We observe only a marginal reduction in estimated WTP compared to the model where net savings is zero.[23] The results also suggest that the

[23]The conclusions are similar when we assume that there is no initial financial wealth and net savings are zero.

level of the market interest rate has a marginal effect on the estimated WTP, and increasing the market rate to 10 percent raises the estimates for the three insurance produces across all types of households. The results thus show that the estimated WTP for insurance is sensitive to the time horizon, but is robust to changes in market interest rate and net savings over the time horizon.

PROBABILITY WEIGHTING

The results indicate that the effects of risk aversion under EUT on the willingness to pay for insurance are rather small, whereas the assumption of rank-dependent expected utility may have a substantial effect on estimated WTP for the three types of insurance. There are some well-known limitations of the Tversky–Kahneman probability weighting function in Equation (5). It does not allow independent specification of location and curvature; it has a crossover point at $p = 1/e = 0.37$ for $\gamma < 1$ and at $p = 1 - 0.37 = 0.63$ for $\gamma > 1$, and it is not increasing in p for small values of γ. Prelec (1998) and Rieger and Wang (2006) offer two parameter probability weighting functions that exhibit more flexibility than (5).[24] The Prelec function is written as

$$w(p) = \exp\{-\eta(-\ln p)^{\varphi}\} \tag{19}$$

and is defined for $0 < p < 1$, $\eta > 0$, and $0 < \varphi < 1$. Numerical problems may arise when $\varphi \to 0$, and when $\varphi = 0$ this function is reduced to the Power function:

$$w(p) = p^{\eta}. \tag{20}$$

One solution to the numerical instability is to further generalize the function, and estimate a three-parameter version that Andersen et al. (2011) refer to as the Power–Prelec probability weighting function:

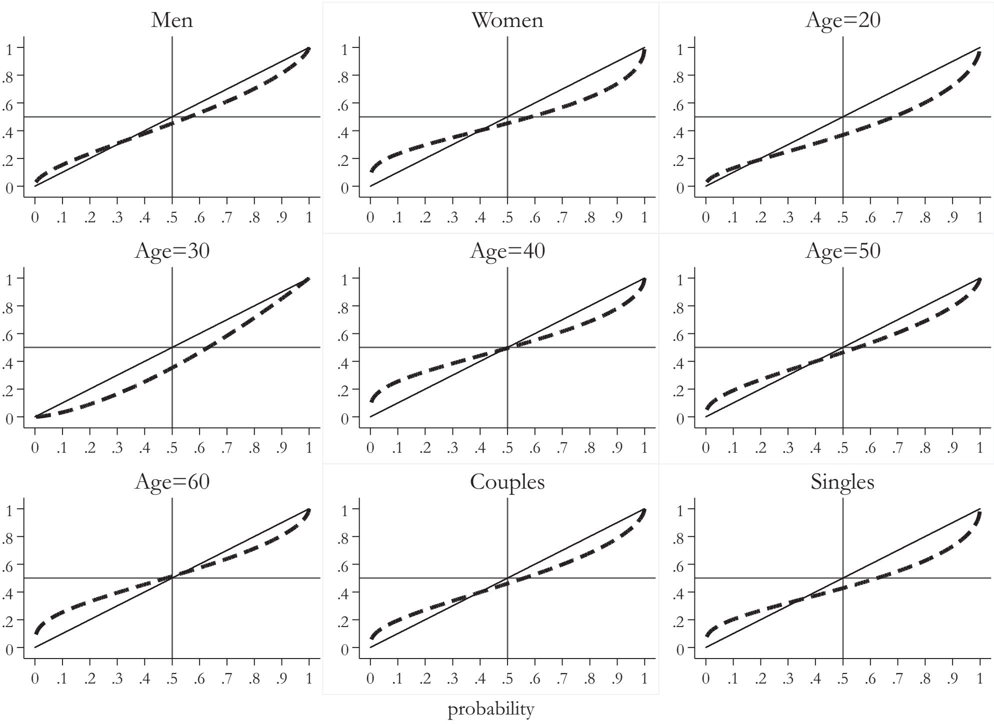
$$w(p) = [\exp\{-\eta(-\ln p)^{\varphi}\}]^{\gamma}. \tag{21}$$

Figure 6 displays the estimated Power–Prelec probability weighting function across sex, age groups, and marital status. We generally observe that subjects have an inverse S-shaped function, except subjects between 30 and 40 years of age who have a strictly convex probability weighting function. Converting the convex probability weighting function into decision weights implies that the no-claims outcome is underweighted and the four other outcomes with positive claims are over-weighted, just like the Tversky–Kahneman function in Equation (5). Hence, we observe that all households place a lower weight on the no-claims outcome and higher weights on outcomes with positive claims.

We can repeat the WTP estimations using the alternative probability weighting functions, and the results are shown in Table 7. Panel A displays the estimated WTP for auto insurance using the Power–Prelec function, and we find the same dramatic

[24]Harrison, Humphrey, and Verschoor (2010) explore the applied use of these more flexible functional forms.

Figure 6
Probability Weighting: Power–Prelec Function



effect as before. The estimated WTP is between 300 and 600 percent higher than the actuarial value of the insurance claims. We find similar effects on estimated WTP for the two other types of insurance.[25] The results thus point to a high WTP for auto, home, and house insurance for all households.

We find that γ in the Power–Prelec function is significantly higher than 1 for subjects younger than 40 years of age, but the estimated coefficient is close to 1 and insignificant for all other households.[26] Hence, the probability weighting functions are similar in shape for the Prelec and Power–Prelec functions. Finally, we find that the η parameter in the Power function is significantly higher than 1 for subjects below 40 years of age, and significantly lower than 1 for those who are 60 years or older. We cannot reject the hypothesis that $\eta = 1$ for men and women, and for singles and couples. A concave probability weighting function ($\eta < 1$) implies that the no-claims outcome is overweighted and outcomes with positive claims are underweighted, and we find that the estimated WTP for auto insurance falls below the actuarial value for the highest age group.

[25]These estimates are provided in Table A5 for home insurance and in Table A6 for house insurance.

[26]The estimated Prelec and Power probability weighting functions are displayed in Figures A1 and A2, respectively.

TABLE 7
Auto Insurance Claims and WTP Using Power–Prelec, Prelec, and Power Functions (Danish Kroner)

	Men	Women	Couples
Panel A: Power–Prelec Function			
Younger than 30 years of age	13,822 (2,364)	9,904 (1,797)	13,469 (2,067)
Between 30 and 40 years of age	7,429 (1,541)	9,536 (2,154)	6,360 (1,213)
Between 40 and 50 years of age	8,527 (1,412)	11,294 (1,661)	10,006 (1,309)
Between 50 and 60 years of age	7,865 (1,489)	6,682 (1,159)	7,989 (1,216)
Older than 60 years of age	4,782 (823)	5,758 (907)	6,644 (970)
Panel B: Prelec Function			
Younger than 30 years of age	15,143 (2,364)	10,021 (1,656)	14,046 (1,698)
Between 30 and 40 years of age	8,992 (1,667)	10,830 (2,182)	7,323 (1,144)
Between 40 and 50 years of age	8,545 (1,442)	10,346 (1,574)	9,505 (1,096)
Between 50 and 60 years of age	7,238 (1,546)	5,623 (1,125)	7,014 (1,168)
Older than 60 years of age	5,626 (1,012)	6,155 (1,031)	7,379 (1,029)
Panel C: Power Function			
Younger than 30 years of age	4,033 (321)	1,900 (154)	3,734 (257)
Between 30 and 40 years of age	3,145 (235)	2,755 (208)	2,635 (164)
Between 40 and 50 years of age	1,964 (154)	2,187 (173)	2,586 (150)
Between 50 and 60 years of age	1,993 (158)	1,412 (112)	2,240 (137)
Older than 60 years of age	1,150 (90)	1,102 (86)	1,529 (86)

CONCLUSIONS

We have shown that it is feasible to estimate the willingness to pay for insurance products. These estimates are based on claims data from the largest insurance company in Denmark, which is mapped to information at Statistics Denmark on annual household income and wealth, and nationally representative estimates of risk aversion and discount rates using controlled experiments. The results show that the willingness to pay is marginally higher than the actuarially fair value under EUT. However, the estimated willingness to pay is significantly higher under RDU theory, and for some households it may be up to 600 percent higher than the actuarial value of the insurance claims.

There is a striking numerical difference between the two results. The experimental evidence on risk attitudes rejects EUT in favor of the RDU model. However, the RDU model leads to an estimated WTP for the three insurance products that may seem implausible in comparison to the information we have on insurance claims from Tryg. The Danish insurance market is characterized by a high degree of market competition and popular indicators such as the Herfindahl–Hirschman Index support this view. This index is close to a value of 1,000, which according to the Horizontal Merger

Guidelines set out by the U.S. Department of Justice and the Federal Trade Commission is consistent with an unconcentrated market.[27] Moreover, the 9-year average rate of return on capital in the insurance industry in 2002–2010 is below the average rate of return on capital in the Danish private business sector, which point to no abnormal returns in the insurance market (Copenhagen Economics, 2013). Hence, the actual market structure in the Danish insurance market is not helpful in discriminating between the two behavioral hypotheses of choice under risk.

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[27]The guidelines are available at http://www.justice.gov/atr/public/guidelines/hmg-2010.html#5c.

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