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by Ulrich Schmidt

No. 1750 | January 2012

Kiel Institute for the World Economy, Hindenburgufer 66, 24105 Kiel, Germany

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Empirical evidence has shown that people are unwilling to insure rare losses at subsidized premiums and at the same time take-up insurance for moderate risks at highly loaded premiums. This paper explores whether prospect theory, in particular diminishing sensitivity and loss aversion, can accommodate this evidence. A crucial factor for applying prospect theory to insurance problems is the choice of the reference point. We motivate and explore two possible reference points, state-dependent initial wealth and final wealth after buying full insurance. It turns out that particularly the latter reference point seems to provide a realistic explanation of the empirical evidence.

Keywords: insurance demand, prospect theory, flood insurance, diminishing sensitivity, loss aversion

JEL classification: D14, D81, G21

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Insurance Demand and Prospect Theory

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Abstract:
Empirical evidence has shown that people are unwilling to insure rare losses at subsidized premiums and at the same time take-up insurance for moderate risks at highly loaded premiums. This paper explores whether prospect theory, in particular diminishing sensitivity and loss aversion, can accommodate this evidence. A crucial factor for applying prospect theory to insurance problems is the choice of the reference point. We motivate and explore two possible reference points, state-dependent initial wealth and final wealth after buying full insurance. It turns out that particularly the latter reference point seems to provide a realistic explanation of the empirical evidence.

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1 Introduction

A major puzzle in insurance economics is the fact that people underinsure low-probability events with high losses and overinsure moderate risks. It is well documented that many people do not take up disaster insurance even though premiums for such insurance contracts are often subsidized (Kunreuther et al., 1978; Kunreuther and Pauly, 2004). A very prominent example for this type of behavior is flood insurance in the USA. At the same time, for modest risk people do often buy insurance with premiums exceeding expected losses substantially (Pashigian et al.,1966; Drèze, 1981; Cutler and Zeckhauser, 2004; Kunreuther and Pauly, 2006; Sydnor, 2010). Examples here are demand for low deductibles and markets for extended warranties or cellular-phone insurance. Beside the cited evidence from the field, also several experimental studies indicate that – holding loading factor and expected loss constant – the rate of insurance take-up increases with the probability of the loss (Slovic et al., 1977; McClelland et al., 1993; Ganderton et al., 2000; but see also the contrary results of Laury et al., 2008).

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The standard theory of decision making under risk, expected utility (EU) theory, is not able to explain these phenomena. Under EU a subject will buy full insurance if and only if premiums are fair, i.e. equal expected losses. This excludes not taking up subsidized flood insurance or buying highly loaded cellular-phone insurance. Also fitting the demand for low deductibles to EU leads to implausible high degrees of risk aversion (Sydnor, 2010). While EU is primarily a normative theory of decision making under risk, also prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992) – the most prominent descriptive theory – has not yet been employed to organize the evidence. The main problem, as argued by Sydnor (2010), is the fact that the decision to take up insurance is determined in the loss domain, if the reference point, as usually assumed, is given by initial wealth. Since subjects in prospect theory (PT) are assumed to be risk seeking in the loss domain, the high insurance demand for modest risks should not be observed.

The present note provides a more detailed analysis of insurance demand under PT. In particular, we argue that it is questionable whether initial wealth is the right choice of the reference point for insurance problems. We propose two alternative reference points which both imply that the rate of insurance take-up increases with the probability of a loss.

2 The Model

In order to keep the analysis simple we focus on a model with only two states of the world, in one of which a loss L will occur. Initial wealth is given by w such that in the absence of an insurance contract state-dependent wealth equals either w or w – L. In most cases, the reference point in PT is assumed to be given by the status quo. Sydnor (2010) therefore takes w as reference point. However, a new variant of prospect theory proposed by Schmidt et al. (2008) allows for state-dependent reference points. Since the status quo is also state-dependent for insurance problems it seems reasonable to take w as reference point for the state with loss and w – L as reference point for the state in which the loss L occurs. Doing so implies that keeping the status quo (i.e. not taking up insurance) leads to neither gains nor losses in both states. The consequences for insurance demand with this reference point will be analyzed in section 2.1. More precisely, we suppose that the subject has the choice between either full insurance or no insurance and derive the loss probability for which full insurance is optimal. It turns out that a higher probability of the loss indeed raises the propensity to take up insurance.

Taking the status quo as reference point is, however, not necessarily the right choice from an empirical point of view. For instance, Hershey and Schoemaker (1985) and Bleichrodt, et al. (2001) found that people take one of the alternatives (usually a safe option) as their reference point and evaluated the outcomes of the other alternative relative to this reference point (see also Stalmeier and Bezembinder 1999, Morrison 2000, Robinson, Loomes, and Jones-Lee 2001, van Osch et al. 2004). For our choice between full or no insurance this means that the wealth after buying full insurance is a perhaps a more reasonable choice for the reference point. Insurance demand for this reference point will be analyzed in section 2.2. Also in this case the evidence discussed in the introduction is implied and here for more relevant probability ranges than in section 2.1.

PT differs from EU by reference dependence and probability weighting. The theory and also the evidence for weighting probabilities of rare events is however not entirely conclusive. In original prospect theory very small probabilities are either overweighted or rounded to zero. In order to circumvent this ambiguity, our analysis refrains from probability weighting and considers prospect theory with untransformed probabilities. This means that we analyze the consequences of reference dependence in isolation. Reference dependence in PT is characterized by diminishing sensitivity (the value function v is concave for gains and convex for losses) and loss aversion (the value function is steeper for losses than for gains). In order to derive numerical values for the critical probabilities we employ the following value function proposed by Tversky and Kahneman (1992):

$$(1) \qquad v(x) = \begin{cases} x^{\alpha} & \text{if } x \geq 0 \\ -\lambda|x|^{\alpha} & \text{if } x < 0. \end{cases}$$

The value function exhibits diminishing sensitivity for $\alpha < 1$ and loss aversion for $\lambda > 1$. Median parameters observed in the experimental study of Tversky and Kahneman (1992) correspond to $\alpha = 0.88$ and $\lambda = 2.25$.

2.1 Status Quo as Reference Point

We assume that the subject can buy full insurance for the fair premium pL where p equals the probability of the loss. If full insurance is taken up, final wealth equals w – pL in both states. Otherwise final wealth equals the status quo and is given by either w or w – L. This is also the state-dependent reference point. Therefore, if the subject refrains from taking up insurance there is a gain of zero in both states, i.e. the utility level equals zero (note that v(0) = 0 is always required in PT). For full insurance there is a gain of w – pL – (w – L) = (1 –p)L with probability p and a loss of w – pL – w = – pL with probability 1 – p. Consequently the subject will take up insurance if

$$(2) \qquad pv((1-p)L) + (1-p)v(-pL) > 0.$$

In order to explain the evidence that insurance take-up is increasing with p, the left-hand side of inequality (2) should be increasing in p, i.e. it should hold that

$$(3) \qquad v((1-p)L) - pLv'((1-p)L) - v(-pL) - (1-p)Lv'(-pL) > 0.$$

It is easy to see that this inequality cannot be satisfied in all cases. For instance a violation can be established for p converging to zero since $v(L) > Lv'(0_-)$ cannot hold in the presence of diminishing sensitivity and loss aversion. For p converging to unity (3) holds for value functions satisfying $-v(-L) > Lv'(0_+)$. Therefore, we can expect that the model is consistent with the evidence if at all then only for relatively high loss probabilities. This is confirmed by considering the value function defined in (1).

<u>Proposition 1:</u>

For the value function defined in (1) with $\alpha < 1$ inequality (2) is satisfied if and only if

$$p > \frac{\lambda^{1/(1-\alpha)}}{1+\lambda^{1/(1-\alpha)}}$$

Proposition 1 shows that the model is in principle compatible with the evidence that people do not take up insurance for low loss probabilities. However, for realistic values of α and λ the condition in Proposition 2 leads to quite high probabilities. If we take the values of Tversky and Kahneman ($\alpha = 0.88$ and $\lambda = 2.25$) we get for instance $p > 0{,}999$, which means that subjects would take up insurance only for losses which are nearly certain. In total we can conclude that the status quo as reference point does not provide an empirically convincing accommodation of the evidence

2.2 Full Insurance as Reference Point

Wealth after taking up full insurance equals $w - pL$ in both states. Taking this wealth as reference point, buying full insurance leads to a utility level of zero. If the subject decides instead not to take up insurance at all, there is a loss of $w - L - (w - pL) = -(1 - p)L$ with probability p and a gain of $w - (w - pL) = pL$ with probability $1 - p$. Consequently, full insurance will be bought if

(4) $\quad pv(-(1 - p)L) + (1 - p)v(pL) < 0.$

In order to explain the evidence that insurance take-up is increasing with p, the left-hand side of inequality (4) should be decreasing in p, i.e. it should hold that

(5) $\quad v(-(1 - p)L) + pLv'(-(1 - p)L) - v(pL) + (1 - p)Lv'(pL) < 0.$

Also (5) may or may not be satisfied. It holds for p converging to zero if $Lv'(0_+) < v(-L)$ but is violated for p converging to unity since $Lv'(0_-) > v(L)$ in the presence of diminishing sensitivity and loss aversion. Applying the value function defined in (1) we can get again more concrete results.

Proposition 2:
For the value function defined in (1) with $\alpha < 1$ inequality (4) is satisfied if and only if

$$p > \frac{1}{1+\lambda^{1/(1-\alpha)}}$$

Proposition 2 reconfirms that prospect theory with full insurance as reference point is compatible with the evidence. Compared to Proposition 1 insurance take-up occurs here already for small probabilities. Considering again the values of Tversky and Kahneman ($\alpha = 0.88$ and $\lambda = 2.25$) subjects will take up full insurance iff $p > 0{,}0012$, i.e. only very rare risks will be uninsured. This value for p is however very sensitive to the value of α. For e.g. $\alpha = 0.5$, which is also a quite realistic value, the condition would change to $p > 0.165$.

3. Conclusions

The present paper has considered insurance demand under prospect theory in a very simple model where subjects have the choice between taking up either full insurance at a fair premium or no insurance at all. In one variant of the model we considered the status quo as reference point which is state-dependent in the case of insurance problems. In a second variant we have argued that according to the evidence of Hershey and Schoemaker (1985) and Bleichrodt, et al. (2001) it is realistic that individuals may take final wealth after buying full insurance as their reference point. Both variants of the model are in principle consistent with the evidence that the rate of insurance take-up is increasing with the loss probability. The second variant of the model seems to be however more realistic as insurance will be taken up here already for relatively low probabilities. Taking the functional form of value function proposed by Tversky and Kahneman (1992) with $\lambda = 2.25$ and assuming that the parameter α is distributed between 0.5 and 0.99 in the population implies that as the loss probability (p) is increasing more and more subjects will take up insurance until $p = 0.165$ when all subjects are fully insured.

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