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« The Effect of Ambiguity Aversion on Self-insurance and Self-protection »

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Motivation

- Some risks are ambiguous (i.e., have « unknown » probability distributions)
- Does ambiguity justify more preventive efforts?
- Does ambiguity aversion reinforce risk aversion?

Some results

We distinguish self-insurance (reduction in the size of the loss) from self-protection (reduction in the probability of the loss)

- Ambiguity aversion always raises the **marginal cost of preventive efforts** (self-insurance + self-protection) under risk aversion

- Ambiguity aversion always raises the **marginal benefit of self-insurance** under risk aversion;

  Moreover, this effect on marginal benefit dominates the previous effect on marginal cost, so that ambiguity aversion always raises self-insurance

- The effect of ambiguity aversion on the **marginal benefit of self-protection** is unclear;

  But no effect in some regular cases, so that ambiguity aversion reduces self-protection due to the effect on marginal cost

Ongoing research (no paper yet!)

- Based on :

Alary, D., Gollier, C. and N. Treich, « The effect of ambiguity aversion on self-insurance and self-protection », work in progress.

See also Treich N., 2009, « The value of a statistical life under ambiguity aversion », *Journal of Environmental Economics and Management*, forthcoming.

Outline

1. Classical expected utility approach: The effect of risk aversion on self-insurance (SI) and on self-protection (SP)

2. Modeling ambiguity and ambiguity aversion

3. Willingness to pay for SI and SP under ambiguity aversion

4. More general results on the effect of ambiguity aversion

Self-insurance under expected utility

- Reduction of the size loss if an accident (e.g., earthquake, flood, fire) occurs – example sprinkler systems

- A simple self-insurance decision model under expected utility theory:

  $$Max_e\ (1-p)u(w-e) + pu(w-e-L(e))$$

  p: probability of loss, ***e:*** self-insurance effort

  L(e): loss, with $L(.)>0$, $L'(e)<-1$, $L''(.)>0$

  w: initial weath, ***u(.):*** vNM utility function, with $u'(.)>0$ and $u''(.)\leq 0$

Optimal self-insurance effort

- First order condition

  $g(e) = -(1-p)u'(w-e) + p(-1-L'(e))u'(w-e-L(e)) = 0$

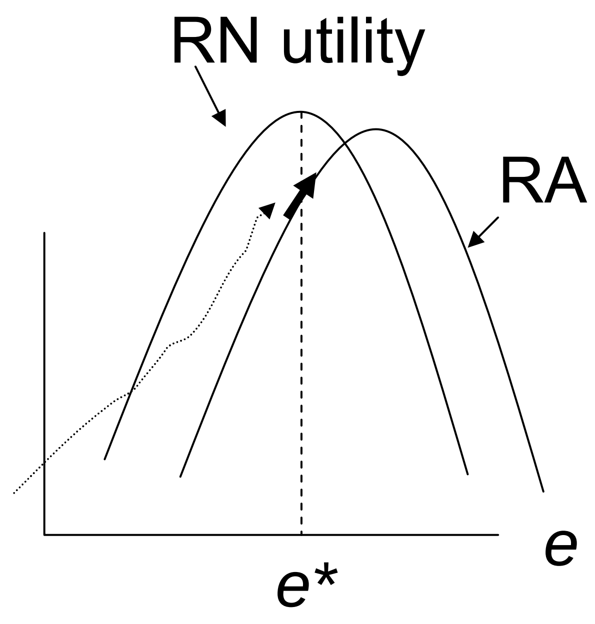
- Under risk neutrality

  $-1-pL'(e^*) = 0$

- Risk aversion increases self-insurance iff $g(e^*) \geq 0$

  $g(e^*) = (1-p)(u'(w-L(e^*)-e^*)-u'(w-e^*)) \geq 0$

- Always true. Risk averse agents thus invest more in self-insurance than risk neutral agents



Self-protection under expected utility

- Reduction of the probability of the loss
- A simple self-protection decision model under expected utility theory:

$$Max_e\ (1-p(e))u(w-e) + p(e)u(w-L-e)$$

with $p(.)\in[0,1]$, $p'(.)<0$ and $p''(.)>0$

- First order condition

$$g(e) = -p'(e)(u(w-e)-u(w-L-e)) - (1-p(e))u'(w-e) - p(e)u'(w-L-e) = 0$$

Risk aversion and self-protection

- Risk aversion may decrease, and not increase, self-protection (Dionne and Eeckhoudt, 1985)
- Depends on whether *p* is lower or larger than ½, and on conditions on *u(.)* (Ehrlich and Becker, 1972; Darchaoui et al., 2004; Eeckhoudt and Gollier, 2005)
- Intuition: ½ is the critical probability threshold below which a reduction in probability reduces the variance of the risk

Ambiguity

- Probability of loss is « unknown »
- Compare for instance two situations:

i) the probability of loss is known ***p=1/3***, or

ii) the probability of loss ***P*** is unknown, but with « expectation » ***EP=1/3*** (to keep the risk of same magnitude)

- Under ambiguity neutrality (i.e., expected utility), the objective is linear in probability, and the two situations are equivalent
- Under ambiguity theories, the two situations are not equivalent

Ellsberg’s suggested experiment

Act	30 red balls	black balls	yellow balls
X	$W	0	0
Y	0	$W	0
X’	$W	0	$W
Y’	0	$W	$W

Many people would choose X>Y and Y’>X’
Inconsistent with Savage’s theory of a unique subjective probability

Ambiguity aversion

- Experimental evidence (e.g., Sarin and Weber, 1993, Halevy, 2007) and survey data (e.g., Viscusi, 1998, Chesson and Viscusi, 2003)
- Some market evidence (e.g., Camerer and Weber, 1992)
- Explain some empirical puzzle (e.g., in finance, Mukerji and Tallon, 2001, Chen and Epstein, 2002)
- But difficult to estimate ambiguity and ambiguity aversion, and introduce new anomalies, especially for intertemporal decision-making (e.g., Al-Najjar and Weinstein, 2009)

Why would individuals be ambiguity averse?

- Open question
- Using brain imaging, Camerer et al. (2007) find evidence that the amygdala is more active under ambiguity conditions, and notice that the *« amygdala has been specifically implicated in processing information related to fear »* (Camerer et al., 2007, p. 131)
- Emotional fearful situations, like life-threatening situations, lead individuals to react to probabilities and outcomes in a manner that is very different from that postulated by expected utility (Loewenstein, 2007)

Some models with « ambiguity aversion »

- Let $V(p) = (1-p)u(w) + pu(w-L)$ the EU conditional on $P=p$
- Gadjos-Takashi-Tallon-Vergnaud (2008) (see also, Maccheroni-Marinacci-Rustichini, 2006):

$$(1-\mu)\ EV(P) + \mu\ V(p_{high})$$

in which μ is the uncertainty aversion parameter

- Klibanoff-Marinacci-Mukerji (hereafter KMM) (2005)

$$Ø^{-1}[EØ[V(P)]]$$

in which $Ø$ concave is equivalent to ambiguity aversion

Polar case: Risk elimination

- From now, I will assume KMM preferences
- Risk elimination is an ultimate form of self-insurance (where the loss equals zero) or self-protection (where the probability of loss equals zero)
- Let ***C*** the WTP for risk elimination under ambiguity aversion

$$U(w-C)=Ø^{-1}[EØ[V(P)]] \leq Ø^{-1}[Ø[EV(P)]] = V(EP)=u(w-C_0)$$

with $V(p) = (1-p)u(w) + pu(w-L)$, and where C_0 is ***WTP*** under EU

- Therefore ambiguity aversion raises WTP for risk elimination
- Intuition: eliminating the risk also eliminates the ambiguity

WTP for self-insurance under KMM

- WTP $C(e)$ for loss reduction e

$$E\text{Ø}[(1-P)u(w-C(e))+Pu(w-C(e)-L+e)] = E\text{Ø}[V(P)]]$$

- WTP for infinitesimal self-insurance

$$C'(0)= u'(w-L)\ \hat{E}P \,/\, ((1-\hat{E}P)u'(w)+\hat{E}P\ u'(w-L))$$

where $\hat{E}P = E(P\text{Ø}'[P])/E\text{Ø}'[P] > EP$ ***under Ø concave*** (Monotone likelihood ratio)

- Two effects: ambiguity increases expected marginal cost (denominator) but increases expected marginal benefit (numerator) of self-insurance

- The second effect dominates: ambiguity aversion increases the WTP for self-insurance

WTP for self-protection under KMM

- WTP ***C(e)*** for a reduction ***e*** in the probability of loss

EØ[(1-P+e)u(w-C(e))+(P-e)u(w-C(e)-L)] = EØ[V(P)]]

- WTP for infinitesimal self-protection

C'(0)= (u(w)- u(w-L)) / ((1-ÊP)u'(w)+ÊP u'(w-L))

where ***ÊP = E(PØ'[P])/EØ'[P] > EP under Ø concave*** (Monotone likelihood ratio)

- One effect only: increase in the marginal cost (denominator)
- Ambiguity aversion therefore decreases WTP for self-protection
- Opposite effect of ambiguity aversion on self-insurance vs. self-protection

A more general model

$$Max_e\ Ø^{-1}[EØ[(1-P(e))u(w-e) + P(e)u(w-e-L(e))]]$$

- Model combining both self-insurance and self-protection
- Model studying optimal preventive effort (not only polar cases)
- What's the effect of ambiguity aversion on optimal effort ***e***?
- Remark: ***P(e)*** is a random variable

Results – Three distinct effects

1. Ambiguity aversion always increases **expected marginal cost** of preventive measures (↓**e**)

2. Ambiguity aversion always increases **expected marginal benefit of self-insurance** (↑**e**); moreover this effect dominates the first negative effect of marginal cost

3. Ambiguity aversion has an ambiguous effect on the **expected marginal benefit of self-protection**, depends on how ***P'(e)*** covaries with ***P(e)***

   Intuition: ambiguity aversion leads to « focus » more on high probabilities of loss; thus the effect depends on whether self-protection efforts reduce high probabilities of loss

Extensions?

- Other ambiguity aversion models (seems to lead to similar results)
- More than two states (difficult: not surprising since limited results even under expexted utility – see, e.g., Jullien, Salanié, Salanié, 1999)
- Comparative statics in KMM model: wealth, risk aversion, baseline probability of loss…
- Ambiguous loss *L*
- Add insurance demand (but raises issues concerning the behavior of insurers)
- State-dependent preferences (Treich, 2009)

Conclusions

- Ambiguity aversion always increases self-insurance (and therefore reinforces the effect of risk aversion)
- Ambiguity aversion may well decrease self-protection; depends on the relative efficiency of the risk-reduction technology in the « bad states »
- Are there real life examples of these effects? Are ambiguity and ambiguity aversion important to understand individual preventive efforts?
- Policy implications? (tricky because ambiguity theories raise normative issues)