Prevention and risk perception : theory and experiments

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Introduction

- Prevention : a set of costly measures which aim to reduce risk ;
- Two main types of prevention :
  - reduction in loss probabilities (self protection, primary prevention, mitigation) ;
  - reduction in loss amounts (self insurance, secondary prevention, adaptation).
- Why this distinction ?
  - different types of risk reduction ;
  - different determinants and different relations with risk attitudes.

Introduction

Prevention is an important topic both for insurance companies and for public policy makers ;

- Prevention levels are often below expected and socially optimal ones ;
- The efficiency of financial, and no financial incentives is often below the target levels.

Behavioral economics models and experiments can allow :

- to better understand observed behaviors ;
- to propose more efficient incentives.

The basic model

- An individual with initial wealth w faces a risk of loss characterized by a r. v. $X \in [0, S]$, d.f. $F_X(x)$;
- Prevention is characterized by an intensity $e \in [0, e_{max}]$, a cost function $c(e)$ with $c' > 0, c'' > 0$ and an "efficiency" or risk transformation function $X(e)$ (with d.f. $F(x, e)$).
  - Self insurance : $X(e) = X - g(e)$ for $X > 0, g'(e) > 0$;
  - Self protection : $(w - X(e)) DS1 (w - X)$, $X(e) \in [0, S]$.

Prevention decisions : standard results with EU preferences

In a simple case, with one possible amount of loss S and $P(X = S) = p$:

- self insurance : S becomes $S(e)$ with $S(e) < S$ for any $e > 0$ and $S'(e) < 0$;
- self protection : p becomes $p(e)$ with $p(e) < p$ for any $e > 0$ and $p'(e) < 0$.

Prevention decisions : basic results with EU preferences

- Individual preferences are represented by the Expected Utility model ;
- Prevention level e^* is solution of the following problem :

$$Max_e \; Eu(w - X(e) - c(e))$$

Prevention and risk attitudes

- for risk averse individuals ($u'' < 0$), $e^* \in]0, e_{max}[$ verifies :

$$\frac{\partial Eu(w - X(e) - c(e))}{\partial e} = 0$$

- for risk neutral individuals ($u'' = 0$), $e^* \in]0, e_{max}[$ verifies :

$$-\frac{\partial E(X(e))}{\partial e} = c'(e)$$

- for risk lovers ($u'' > 0$), only $e^* = 0$ or $e^* = e_{max}$.
  $e^* = e_{max}$ if :

$$Eu(w - X(e_{max}) - c(e_{max})) > Eu(w - X)$$

Prevention decisions : basic results with expected utility preferences

Prevention decisions for risk averse individuals ($u'' < 0$) : one amount of loss

- Self insurance :
  An interior e^* verifies :
  $c'(e)\left[pu'(w - S(e) - c(e)) + (1-p)u'(w - c(e))\right] =$
  $-p\, S'(e)u'(w - c(e) - S(e))$

An increase in risk aversion increases the optimal level of self insurance.

Prevention decisions : basic results with expected utility preferences

Prevention decisions for risk averse individuals ($u'' < 0$) : one amount of loss

- Self protection : An interior e^* verifies :

  $$c'(e)\left[pu'(w - S(e) - c(e)) + (1-p)u'(w - c(e))\right] = -p'(e)[u(w - c(e)) - u(w - S - c(e))]$$

  An increase in risk aversion has an ambiguous impact on self protection, two effects :

  - decrease in loss probability ;
  - decrease in all wealth levels, included the worst one.

Prevention decisions : basic results with EU preferences

- The Expected utility model has been challenged as a dascriptive model by paradoxes and biaises (Allais 1953 , Kahneman, Tversky 1979) related namely to its incapacity to take into account risk perceptions :
  - Allais paradox ;
  - Framing effects ;
  - Reference points ;
  - Underinsurance against low probabilities events (natural hazards) ;
  - Influence of past experience,...

Rank Dependant Utility (RDU) model

RDU model, proposed by Quiggin (1982), closely related to Kahneman and Tversky's (1979, 1992) Prospect and Cumulative Prospect theory.

Machina (2008) : "the Rank Dependent model (RDU) has emerged as the most widely adopted model in both theoretical and applied analysis"

- Weakens the independance axiom of the Expected utility model ;
- Introduces a "subjective" probability transformation function.

⇒ decision weights are no more systematically equal to probabilities, but can depend on consequences (gains or losses)

⇒ possibility to take into account pessimism, optimism or denial.

- Risk perceptions can thus depend on :
  - past experience, risk domain, emotional variables, ...

Rank Dependant Utility (RDU) model

In the RDU model, preferences representation depends on two functions :

- an utility function u, increasing, continuous and unique up to an increasing affine transformation ;
- a probability transformation function φ such that $\varphi : [0, 1] \rightarrow [0, 1]$, increasing with $\varphi(0) = 0$ and $\varphi(1) = 1$.

For a r.v. X with d.f. $F_X(x)$,

$$V^{RDU}(X) = -\int_{-\infty}^{+\infty} u(x) d\varphi \left[1 - F_X(x)\right]$$

Rank Dependant Utility (RDU) model

If X takes a finite number of values, with $P(X = x_i) = p_i$, $i = 1..n$ and $x_1 \leq x_2 \leq ... \leq x_n$.

$$V^{RDU}(X) =$$

$$= u(x_1) + \varphi(p_2 + ... + p_n)[u(x_2) - u(x_1)] + ... + \varphi(p_n)[u(x_n) - u(x_{n-1})]$$
$$= \sum_{i=1}^{n-1} \left[\varphi\left(\sum_{j=i}^{n} p_j\right) - \varphi\left(\sum_{j=i+1}^{n} p_j\right)\right] u(x_i) + \varphi(p_n) u(x_n).$$

Rank Dependant Utility (RDU) model

Some remarks

- Risk attitudes depend on both u and φ,
- If $u'' \leq 0$:
  - an individual is weakly risk averse if $\varphi(p) \leq p$;
  - an individual is strongly risk averse if $\varphi(p)$ is convex.
- If $\varphi(p) = p$, an individual has EU preferences ;
- If $\varphi(p) \neq p$, the percieved probability of an event can depend on the associated gain or loss for a given decision ;
- if $\varphi(p) \leq (\geq) p$ for any p, an individual is called pessimist (optimist) ;
- if $\varphi'(p) \leq 1$ for any $p \in]0, 1[$, an individual is called fatalist.

Prevention decisions with RDU model

Self insurance

- The optimal level of self-insurance is solution of :

$$Max_e \; V_{RDU}(e)$$

$V_{RDU}(e) =$
$u(w - S(e) - c(e)) + \varphi(1-p)\left[u(w - c(e)) - u(w - S(e) - c(e))\right]$

- $e*$ verifies :
$c'(e)\left[(1-\varphi(1-p))u(w - S(e) - c(e)) + \varphi(1-p)u(w - c(e))\right] =$
$-(1-\varphi(1-p))S'(e)u'(w - c(e) - S(e))$

- e^* depends on $\varphi(1-p)$: $\varphi(1-p) > (1-p)$ decreases the marginal benefit of prevention.

Prevention decisions with RDU model

Self protection

- The optimal level of self-protection is solution of :

$$Max_e \; V_{RDU}(e)$$

$V_{RDU}(e) =$
$u(w - S - c(e)) + \varphi(1 - p(e)) \left[u(w - c(e)) - u(w - S - c(e)) \right]$

- e^* verifies :

$c'(e) \left[(1 - \varphi(1 - p))u(w - S(e) - c(e)) + \varphi(1 - p)u(w - c(e)) \right] =$

- p'(e)$\varphi'(1 - p(e))[u(w - c(e)) - u(w - S - c(e))]$

- e^* depends on $\varphi'(p)$: perception of probability modifications ;
- if $\varphi'(p) < 1$ for any p (the individual is fatalist), his level of self protection will be low, even if he is pessimist.

Health Prevention and Savings : How to Deal with Fatalism ? (Etner, Jeleva 2017)

- Long term care is an important issue as well for insurance compagnies as for public authorities ;
- Even in developped countries, private insurance market for these risks is thin, and expenditures are mainly caried by public systems and individuals ;
- The efficiency of this expenditures repartition is not established, as well as its relation with individual prevention decisions ;
- Understanding individual health prevention and savings decisions can be useful for the design of optimal public policies for long term health risk management.

Health Prevention and Savings : How to Deal with Fatalism

- Aim of the paper :
  - analyze the individual trade off between primary prevention and savings focusing on the role of risk perception ;
  - propose a public policy combining prevention subsidies with co-payment of health care expenditures.
- Main results :
  - in studying the impact of risk perception on individual decisions, two types of pessimists have to be distinguished : moderate pessimists and fatalists ;
  - the optimal trade off between prevention subsidies and co-payment strongly depends on both the distribution of wealth in the population and risk perception.

Health Prevention and Savings : the model

- Two period model, individuals derive utility from consumption and health ;
- Preferences are assumed separable in time and represented by the RDU model ;
- At period 1, individual i, with health status, H_0, receives an income, w_i, pays taxes, τw_i, and consumes c_i ;
- The individual faces a long-term care risk (health risk). In period 2, two states of health are possible. With probability p, the individual falls ill (or becomes dependent) and has to pay $(1-\rho)\,T$ for an (imperfect) treatment.
- To reduce health risk, two tools are available :
  - primary prevention h_i, with an individual marginal cost $(1-\theta)$;
  - savings s_i with a return, $R = 1 + r$, where r is the interest rate.

Individual health prevention and savings

Agent i's prevention and saving levels are solutions to the following program :

$$\max_{s_i, h_i \geq 0} U\left(w_i\left(1-\tau\right)-s_i-\left(1-\theta\right)h_i, H_0\right)+$$
$$\delta\left[\left(1-\varphi\left(1-p\left(h_i\right)\right)\right)U\left(Rs_i-\left(1-\rho\right)T, \underline{H}\right)+\varphi\left(1-p\left(h_i\right)\right)U\left(Rs_i, \overline{H}\right.\right.$$

Remark : the probability transformation function, φ can be discontinuous at 0 and 1 but is always right differentiable at 0 and left differentiable at 1.

Assumption : For all $\underline{c}$ *and* $\overline{c}$ such that, $\overline{c} \geq \underline{c}$, $U_1(\underline{c}, \underline{H}) \geq U_1(\overline{c}, \overline{H})$. (always true if $U_{12}(c, H) \leq 0$).

The impact of risk perception on prevention and savings decisions

- Not only the gap between p and $\varphi(p)$ matters, but also the slope of $\varphi(p)$.

Proposition 1

Consider 2 individuals differing only in their probability transformation functions, denoted by φ_1 and φ_2. Then, for a fixed level of savings, $h_2^* > h_1^* \Leftrightarrow \varphi_2'(1 - p(h_2^*)) > \varphi_1'(1 - p(h_2^*))$.

Proposition 2

Consider 2 individuals differing **only** in their probability transformation functions, denoted by φ_1 and φ_2 with for any $p \in]0, 1[$, $p > \varphi_i(p)$, $i = 1, 2$. If, for any $p \in]0, 1[$, $\varphi_2'(1 - p) > \varphi_1'(1 - p)$, $s_1 > s_2$ and $h_2 > h_1$.

Social optimum

- The population of N individuals is divided into n groups with respect to risk perception, π_i is the proportion of individuals of type i, $i = 1$ to n.
- $\sum_{i=1}^{n} N\pi_i p(h_i)$: number of individuals who become sick in the second period.
- The cost of treatment depends on the number of sick individuals : $T = T\left(\sum_{i=1}^{n} N\pi_i p(h_i)\right)$.

Social optimum

- Due to externality, the optimal level of health prevention is larger than obtained in the *laissez-faire* setting, even for a standard social welfare function.
- To reconcile the decentralized choices and the efficient allocation, the government can subsidize health prevention and finance part of treatment costs.
- Due to informational asymetries, subsidies and co-payment are the same for all individuals.

Social optimum

The social welfare function, $W(\theta, \rho)$, is :

$$
\begin{aligned}
W(\theta,\rho) \equiv & \sum_{i=1}^{n} N\pi_i \left[U\left(w_i(1-\tau) - s_i(\theta,\rho) - (1-\theta) h_i(\theta,\rho), H_0\right) \right. \\
+ & \ \delta\left(1-\varphi_i\left(1-p\left(h_i(\theta,\rho)\right)\right)\right) U\left(Rs_i(\theta,\rho) - (1-\rho) T(.), \underline{H}\right) \\
+ & \left. \delta\varphi_i\left(1-p\left(h_i(\theta,\rho)\right)\right) U\left(Rs_i(\theta,\rho), \overline{H}\right) \right]
\end{aligned}
$$

Social optimum

The government's program is :

$$\max_{\theta,\rho} \; W(\theta,\rho)$$

subject to the governement budget constraint :

$$\tau \sum_{i=1}^{n} N\pi_i w_i = \theta \sum_{i=1}^{n} N\pi_i h_i(\theta,\rho) + \rho T \left(\sum_{i=1}^{n} N\pi_i p(h_i(\theta,\rho)) \right) \times \sum_{i=1}^{n} N\pi_i p(h_i$$

where $h_i(\theta,\rho)$ and $s_i(\theta,\rho)$ are the best responses of agent of type i to a subsidy θ and a co-payment ρ.

To focus on the trade-off between savings and prevention, we analyze the case of a given government budget and thus maintain the amount of taxes as fixed.

Social optimum : some numerical simulations

- The population is composed of two types of individuals who may differ in their wealth and in their risk perception.
- Utility function : linear in health and CRRA in wealth : $u(c, H) = H\frac{c^{1-\alpha}}{1-\alpha}$ (see Finkelstein et alii (2011)).
- Probability transformation function : $\varphi_i(p) = b_i p^{\beta_i}$ with $b_i > 0, \beta_i \geq 1$ where b_i measures the degree of fatalism, and β_i, the degree of pessimism (see Prelec 1998).
- Relation between prevention expenses and illness probability : $p(h) = \frac{p_0}{1+p_0 h}$
- Cost of treatment : increasing with the number of sick individuals : $T = t_0 + t_1 \times \sum_{i=1}^{n} N\pi_i p(h_i(\theta, \rho))$ with $t_0 \geq 0$ and $t_1 \geq 0$.

Social optimum : some numerical simulations

- the poorest individuals are the most pessimist :
  - these individuals have a high investment in prevention and a low level of savings ;
  - wealth inequalities in the sick population increase and the social health insurance system becomes more efficient than prevention subsidies.
- the poorest individuals are the most fatalist :
  - these individuals have a low investment in prevention and a high level of savings ;
  - prevention subsidies are the more efficient instrument even if their efficiency is low, the number of sick individuals is high.

Health prevention and savings : concluding remarks

- Risk perception is important to understand long term prevention and savings behavior ;
- A distinction has to be made between overestimation of the probabilities of unfavorable events (pessimism) and underestimation of probabilities modifications (fatalism) ;
- For the design of public policy, it is necessary to take into account the relation between wealth and risk perception, for instance, an increase in fatalism does not have the same implications on policy variables when it concerns the rich part of the population as when it concerns the poor one.

Prevention decisions in experiments

Lab and field experiments can contribute :

- to a better understanding of prevention determinants (risk domain, individuals risk attitudes, social preferences, personnality traits, past experience) ;
- to test some financial and non financial incentives (taxes, subsidies, informational nudges, pair effects,...)

Prevention decisions in experiments

Air Pollution and Hazard Mitigation : A Contextualized Public Good Experiment Incorporating Risk, Etner, Farrow, Jeleva (2018)

- Aim : Test the impact of different information messages on the consequences of air pollution (environment or health) on individual and collective measures of reducing risks from air pollution.
- Experimental design :
  Main task : choice of contribution to 2 types of risk reduction instruments related to air pollution :
  - instrument 1 : individual efficiency (air purifier, rush hour avoidance, mask wearing, ...) ;
  - instrument 2 : collective efficiency (reduction of polluting emissions, public transport, cycling, car sharing, etc.)

Prevention decisions in experiments

- An adapted version of a public good game ;
- Several treatments :
  - Precise information / ambiguous information on the probability of illness due to air pollution ;
  - Information on the impact of air pollution on health / environment.
- Control variables
  - Choice of lotteries for the elicitation of attitude towards risk and ambiguity ;
  - Environmental sensitivity ;
  - Altruism.

Hypotheses tested :

- H1 Communication on the benefits of the contribution in terms of health is more effective than that on the benefits in terms of the environment ;
- H2 The contribution to both risk reduction instruments is lower when the risks are ambiguous.

Concluding remarks

- the efficiency of incentive policies for prevention can be improved by a deeper analysis of risk perceptions and behavior determinants ;
- taking into account individual heterogeneity can allow a better targeting of policies ;
- experiments allow to test ex ante different incentive policies and find the best trade off between financial and non-financial incentives.