On the design of optimal health insurance contracts under ex post moral hazard

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Demand management and ex post moral hazard

1 : Instruments for health care regulation :

- demand management : copayment, deductibles...
- supply management : managed care, incentives to providers

2 : Demand management ⇒ ex post moral hazard (Arrow,1963; Pauly,1968, Zeckhauser,1970) :

- trade-off between ex ante risk sharing and ex post incentives
- conventional wisdom : " a perverse incentive toward overexpenditure" (Zeckhauser, 1970).

Objectives of the paper

1. Analyzing the ex post moral hazard problem in an **optimal contract** setting, in the line of Blomqvist (1997) : what is robust ? what depends on assumptions on preferences ?
2. Ma and Riordan (2002) challenge the conventional wisdom about the tendency toward overexpenditure. We reconsider this issue in an optimal insurance setting.

Notations

R : monetary wealth

h : health level

Utility : $U(R, h)$

w : initial wealth

T : net payment for health care

$R = w - T$

$\widetilde{x} \in [0, x_+]$: severity of illness, with c.d.f. $F(x)$ and $f(x) = F'(x)$

m : health care expenses

$h = h_0 - \gamma x(1 - v(m))$

$v(0) = 0, v(m) \in (0, 1)$ if $m > 0, v' > 0, v'' < 0$

Two models

- Monetary loss model

$$U(R, h) = u(R + h), u' > 0, u'' < 0.$$

- Utility loss model

$$U(R, h) = u(R) + h, u' > 0, u'' < 0.$$

In this presentation, we restrict ourselves to the utility loss model : more realistic because of the income effect on health care demand.

First best allocation

$\{m(x), T(x)\}_{|x \in [\infty 0, x_+]}$ maximizes the individual's expected utility

$$\int_0^{x_+} [u(w - T(x)) - \gamma x(1 - v(m(x))] f(x) dx, \tag{1}$$

subject to

$$\int_0^{x_+} [T(x) - m(x)] f(x) dx \geq 0. \tag{2}$$

Proposition *The first-best allocation $m^*(.)$, $T^*(.)$ is such that $T^*(x) = t^*$ and $\gamma x v'(m^*(x)) = u'(w - t^*)$ for all x where $t^* = E(m^*(\widetilde{x}))$.*

Proportional coinsurance (1)

$$T = m + P - I$$

$$I = \alpha m, \text{ with } \alpha \in [0, 1]$$

$$m(x, \alpha) = \arg\max_m \{u(w - P - (1 - \alpha)m) - \gamma x(1 - v(m)\}$$

$$P = \alpha \mathbb{E}[m(\widetilde{x}, \alpha)]$$

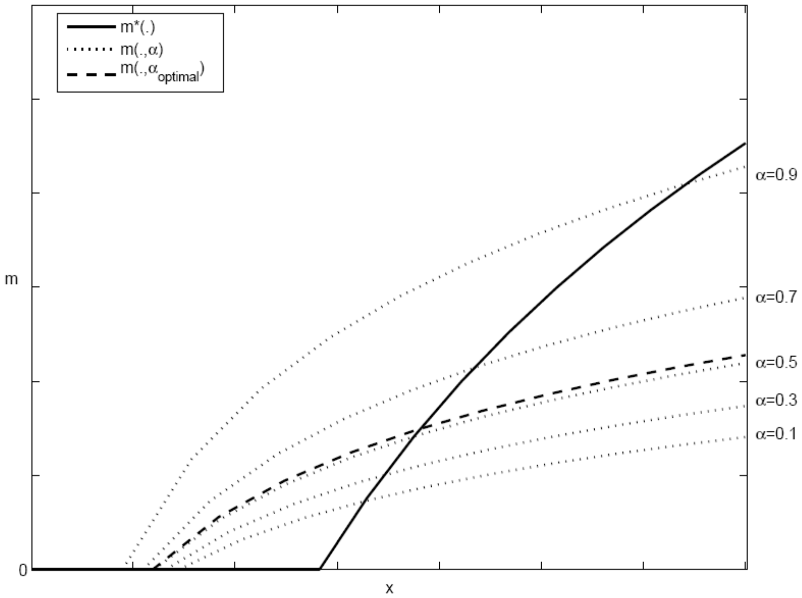
Proportional coinsurance (2)

Proposition *The optimal proportional coinsurance scheme is such that* $0 < \alpha < 1$ *and there is an illness severity threshold* $\widehat{x}(\alpha) > 0$ *such that* $m(\widehat{x}(\alpha), \alpha) = m^*(\widehat{x}(\alpha))$ and

$$\begin{aligned} m(x, \alpha) &> m^*(x) \quad \text{if} \quad x < \widehat{x}(\alpha), \\ m(x, \alpha) &< m^*(x) \quad \text{if} \quad x > \widehat{x}(\alpha). \end{aligned}$$

Simulations

$u(R) = 1 - e^{-\sigma R}$,
$v(m) = 1 - e^{-\eta m}$,
$\widetilde{x}$ is uniformly distributed over $[0, x_+]$,
numerical values for x^+, w, γ, η and σ.


m*(.)
m(.,α)
m(.,α_optimal)
m
0
x
α=0.9
α=0.7
α=0.5
α=0.3
α=0.1

Optimal non-linear insurance (1)

Indemnity schedule $I(m)$:

$$m(x) \in \arg\max_m u(w - P - m + I(m)) - \gamma x[1 - v(m)],$$

$\widehat{I}(x) \equiv I(m(x))$. The allocation $\{m(x), \widehat{I}(x)\}\Big|_{x \in [0,x^+]}$ may also be sustained by a direct revelation mechanism.

Lemma $\{m(.), \widehat{I}(.)\}$ *is incentive compatible if and only if*

$$\frac{d\widehat{I}(x)}{dx} = [1 - \frac{\gamma x v'(m(x))}{u'(R(x))}]\frac{dm(x)}{dx}, \quad (3)$$

$$\frac{dm(x)}{dx} \geq 0, \quad (4)$$

where $r(x) = w - P + \widehat{I}(x) - m(x)$.

Optimal non-linear insurance (2)

$$\max \int_0^{x_+} \left\{ u(w - P + \widehat{I}(x) - m(x)) - \gamma x[1 - v(m(x))] \right\} f(x)dx$$

with respect to $\widehat{I}(.), m(.), h(.)$ and P, subject to

$$\frac{d\widehat{I}(x)}{dx} = h(x)[1 - \frac{\gamma x v'(m(x))}{u'(R(x))}], \widehat{I}(0) = 0, \quad (5)$$

$$\frac{dm(x)}{dx} = h(x), \quad (6)$$

$$h(x) \geq 0 \text{ for all } x, \quad (7)$$

$$\widehat{I}(x) \geq 0 \text{ for all } x, \quad (8)$$

$$P = \int_0^{x_+} \widehat{I}(x) f(x) dx. \quad (9)$$

Optimal non-linear insurance (3)

Assumption : $f(x)$ is non-increasing and $\ln f(x)$ is weakly convex.

Proposition *There are* $\underline{x}$ *and* $\overline{x}$ *such that* $0 < \underline{x} < \overline{x} \leq x_+$ *and*

$$\begin{aligned} \widehat{I}(x) &= 0, dm(x)/dx > 0 \text{ if } 0 < x < \underline{x}, \\ d\widehat{I}(x)/dx &> 0, dm(x)/dx > 0 \text{ if } \underline{x} < x < \overline{x}, \\ d\widehat{I}(x)/dx &= dm(x)/dx = 0 \text{ if } \overline{x} < x \leq x_+. \end{aligned}$$

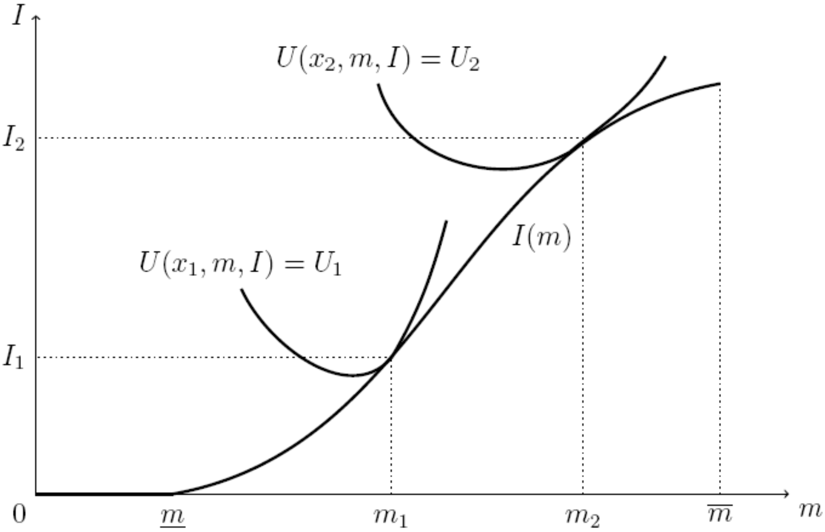
Corollary $\overline{x} = x_+$ *if* x *is uniformly distributed over* $[0, x_+]$.

Optimal non-linear insurance (4)

Proposition *The optimal indemnity schedule $I(m)$ is such that*

$$
\begin{aligned}
I(m) &= 0 \;\; \textit{if} \;\; m \leq \underline{m}, \\
I'(m) &\in (0,1) \;\; \textit{if} \;\; m \in (\underline{m}, \overline{m}), \\
I'(\underline{m}) &= I'(\overline{m}) = 0, \\
I'(\overline{m}) &= 0 \; \textit{if} \; \overline{x} = x_+, I'(\overline{m}) > 0 \; \textit{if} \; \overline{x} < x_+, \\
I(m) &= I(\overline{m})) \;\; \textit{if} \;\; m \geq \overline{m},
\end{aligned}
$$

with $\underline{m} = m(\underline{x})$ and $\overline{m} = m(\overline{x})$.


I
$U(x_2, m, I) = U_2$
I_2
$I(m)$
$U(x_1, m, I) = U_1$
I_1
0
$\underline{m}$
m_1
m_2
$\overline{m}$
m

Conclusion

- As observed by Ma and Riordan (2002) in a different setting, the conventional wisdom on ex post moral hazard is invalid : ex post moral hazard leads to overexpenditures for low severity illness and to underexpenditures for high severity illnesses.

- As shown by Blomqvist (1997) the optimal indemnity schedule is S-shaped, but it always include a deductible (in the utility loss model) and sometimes an upper limit.