Compulsory insurance and voluntary self-insurance: substitutes or complements? A matter of risk attitudes

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Summary:

According to Ehrlich and Becker (1972), insurance and secondary prevention (self-insurance) are substitutes. We extend their model in order to study the effect of a partial compulsory insurance on self-insurance decisions. Our model distinguishes between risk averters and (mixed) risk lovers. In accordance with the economic intuition, risk averters adjust their self-insurance behavior to compensate for the level (too high or too low) of the coverage offered by a compulsory insurance. In contrast, (mixed) risk lovers, even though they would refuse to invest voluntarily in any hedging scheme, freely invest in self-insurance to complete a compulsory partial insurance coverage. We prove that for a (mixed) risk lover, an increase in the partial compulsory insurance coverage induces simultaneously a rise of the marginal benefit from self-insurance and a decrease of its marginal cost. While compulsory insurance and self-insurance are substitutes for risk averters, they are complements for (mixed) risk lovers. This last result brings an unexpected justification for compulsory insurance policies.

Keywords: self-insurance; compulsory insurance; risk attitudes; risk lovers

JEL-Classification: D11; D86 ; G22 ; K32 ; L51

Introduction:

Since Mossin (1968), it is well known that a risk-averse decision maker buys a comprehensive coverage if insurance price is actuarial and a partial coverage if insurance price is more than actuarial. On the contrary, a risk lover would refuse any positive insurance coverage based upon actuarial or more than actuarial prices. Even more, to get insured, a risk lover would require a positive return from the insurer. This condition would involve subsidized rates or/and negative profits for the insurer. For all these reasons, Insurance Theory did not address the issue of risk loving and instead has been shaped by the assumption of risk aversion.

However, as suggested by Kahneman and Tversky (1979) in the loss domain, some economic evidence suggests that individuals may be risk loving. According to the reflection effect, people could be risk averse in the gain domain and risk loving in the loss domain. And precisely, insurance deals with losses… Experimentally, the existence of risk lovers is well documented. For example, the reflection effect is confirmed in Charkravarty and Roy (2009) while Noussair et al. (2014) highlight that about 15 percent of the individuals of large representative sample are risk loving.

On a theoretical point of view, several contributions recently focused on risk loving behavior. Crainich, Eeckhoudt and Trannoy (2013) demonstrate that "combining good with good" is consistent with mixed risk loving (i.e. the property that successive derivatives of the utility function are all positive).[1] It follows that risk lovers are prudent ($u'''(w)>0$) and share this behavior with risk averters. Jindapon (2013) focusing on self-protection (an investment intended to reduce the loss probability according to Ehrlich and Becker (1972)) shows that a risk lover may find optimal to invest in this type of hedging.

In real world, in most insurance markets, insurance is mandatory. Health insurance, car insurance, household insurance, liability insurance are generally compulsory so risk lovers could be more numerous than we think to buy insurance. In this context, the question of risk attitudes may be appear as minor since people have to comply with the law. But compulsory provisions for insurance are generally partial and complemented by voluntary devices:

[1] As developed in Caballé and Pomansky (1996), "mixed risk aversion" corresponds to the fact that the utility function exhibits all derivatives of alternating sign. Eeckhoudt and Schlesinger (2006) and Eeckhoudt, Schlesinger, and Tsetlin (2009) have shown that the preference for "combining good with bad" leads to risk aversion ($u'' < 0$ in the EU model) and explains the alternating signs of the successive derivatives of u. By contrast, with "mixed risk loving", the successive derivatives of the utility function are all positive.

complementary insurance, self-protection and self-insurance.[2] For all these complementary hedging schemes, risk lovers and risk averters may exhibit very different behaviors.

Following this remark, we included risk lovers in our research agenda and studied the impact of a partial compulsory insurance coverage on the demand for self-insurance according to risk attitudes. Since the contribution of Ehrlich and Becker (1972), insurance and self-insurance are considered as substitutes. We extend their model in order to study the effect of a partial compulsory insurance on self-insurance decisions. In the case of risk aversion, our results are in line with the economic intuition: risk averters adjust their self-insurance behavior to compensate for the level (too high or too low) of the coverage offered by a compulsory insurance. By contrast, (mixed) risk lovers, even though they would refuse to invest voluntarily in any hedging scheme, but owing the fact that they are prudent ($u'''>0$), may freely invest in self-insurance to complete a compulsory partial insurance coverage. While compulsory insurance and self-insurance are substitutes for risk averters, they are proved to be complements for (mixed) risk lovers.

Our paper is organized as follows. In Section 1, we shall present the interactions between compulsory insurance and self-insurance decisions for risk averse individuals. Section 2 will be devoted to (mixed) risk lovers and will demonstrate why they are willing to invest in self-insurance in presence of a partial compulsory insurance. The last section will address the political implications of our results.

1. **Compulsory insurance and self-insurance: the case of risk averters**

For risk averse individuals, the demand for self-insurance will depend on whether the compulsory insurance coverage is above or below the optimal level of insurance. To demonstrate this, we suppose an individual endowed with an initial wealth W_0 and facing a probability q to lose a share x_0 of this wealth. However, this individual may have recourse to a self-insurance technology with diminishing returns in order to reduce his exposure to risk.

[2] Since Ehrlich and Becker (1972), self-insurance relates to the expenses reducing the size of the loss in case of accident (example: security seat belt).

We assume that the loss x is a function of the investment in self-insurance “a”: x = x(a), with x’(a) < 0, x’’(a) > 0 and $x(0) = x_0$. We assume that the marginal return of the first unit of self-insurance is higher than the marginal return of actuarial insurance: -x’(0) > 1/q.

Meanwhile, the individual undergoes a compulsory insurance scheme which imposes, in exchange for a compensation $\bar{I} > 0$, to pay an insurance premium $P = p\bar{I} + C$, where p is the unit price of insurance and C the fixed cost. Then, the final wealth is function of the level of the self-insurance investment “a” and, depending on the state of nature, can be written as follows:

- $W_1 = W_0 - p\bar{I} - C - a$, in the absence of accident ;
- $W_1 = W_0 - p\bar{I} - C - a - x(a) + \bar{I}$, in case of accident.

Given the fact that the individual is risk averse, preferences are characterized by U (W), a strictly concave utility function (U '(W)> 0, U' (W) <0). The individual aims at maximizing his expected utility according to his self-insurance choice “a”:

$$\max_{a} \; EU(a) = (1-q)U(W_0 - p\bar{I} - C - a) + qU(W_0 - p\bar{I} - C - a - x(a) + \bar{I}) \qquad (1.1)$$

The following 1st order condition characterizes an interior solution[3] :

$$\frac{\partial \mathrm{EU}}{\partial \mathrm{a}} = -(1-q)U'\left(W_0 - p\bar{I} - C - a\right) - [1 + x'(a)]qU'\left(W_0 - p\bar{I} - C - a - x(a) + \bar{I}\right) = 0$$

This condition can be rewritten in order to respectively show the marginal cost and the marginal benefit of self-insurance:

$$\frac{\partial \mathrm{EU}}{\partial \mathrm{a}} = -\left\{(1-q)U'(W_1) + qU'(W_2)\right\} + \left\{-x'(a)qU'(W_2)\right\} = 0 \qquad (1.2)$$

[3] The second order condition is checked for a risk averter since U’’(.)<0 and x’’(a)>0:
$\frac{\partial^2 EU}{\partial a^2} = (1-q)U''(W_0 - p\bar{I} - C - a) - x''(a)qU'(W_0 - p\bar{I} - C - x(a) + \bar{I} - a) + [1 + x'(a)]^2 qU''(W_0 - p\bar{I} - C - x(a) + \bar{I} - a) < 0$

Then, the individual chooses his level of self-insurance so as to equalize the marginal return of self-insurance to the following expression:

$$-x'(a)=\frac{(1-q)U'(W_1)}{qU'(W_2)}+1 \qquad (1.3)$$

It is then possible to characterize the resulting choice of prevention by comparison with the optimal situation for which the individual freely chooses the insurance amount I. This choice is characterized by maximizing the expression (1.1) as a function both of "a" and I. Then, still showing marginal cost and marginal benefit respectively, we obtain a 1st order condition for optimal insurance:

$$\frac{\partial \mathrm{EU}}{\partial I}=-p\{(1-q)U'(W_1)+qU'(W_2)\}+\{qU'(W_2)\}=0 \qquad (1.4)$$

Combining conditions (1.2) and (1.4), we find that, at the optimum, the marginal return of insurance has to be equal to the marginal return of self-insurance:

$$\frac{1}{p}=-x'(a^*) \qquad (1.5)$$

Comparing equations (1.3) and (1.5), it is possible to characterize the optimal prevention behavior as a function of the compulsory insurance coverage:

- When insurance is compulsory and equal to optimal insurance ($\bar{I}=I*$), we get:

  $$-x'(a)=\frac{(1-q)U'(W_1)}{qU'(W_2)}+1=\frac{1}{p}=-x'(a^*) \qquad (1.6)$$

  And prevention levels are the same for both compulsory and voluntary insurance schemes (a=a*);
- when compulsory insurance provides an insurance coverage below the optimal coverage ($\bar{I}<I*$), the ratio of marginal utilities of expression (1.6) decreases. Indeed, with respect to the optimal situation, W_1 increases and W_2 diminishes; as a consequence: $-x'(a)<\frac{1}{p}=\ -x'(a*)$. It is immediate that the self-insurance investment increases: a> a *.

- When the compulsory insurance exceeds the optimal level of coverage ($\bar{I} > I*$), by a symmetric argument, we find that the level of prevention is reduced: a <a *.

These results are summarized in the following proposition:

Proposition 1: Facing a partial compulsory insurance, the risk averse individual reacts by increasing (respectively decreasing) the level of self-insurance if the compulsory insurance coverage is lower (or upper) to its insurance optimum, for any given insurance tariff.

It is also possible to characterize the effect of a change in one contractual parameters (p or C). For this purpose, let us rewrite condition (1.3) and develop the arguments of marginal utilities:

$$-x'(a) = \frac{(1-q)U'\left(W_0 - p\bar{I} - C - a\right)}{qU'\left(W_0 - p\bar{I} - C - a - x(a) + \bar{I}\right)} + 1 \qquad (1.7)$$

We find a result of substitutability between insurance and prevention. Indeed, when the price of insurance increases, under the DARA (Decreasing Absolute Risk Aversion) assumption, the denominator of the right-hand side of expression (1.7) rises relatively more than the numerator. Therefore, the ratio decreases and equality (1.7) implies that -x '(a) decreases. Finally, “a” increases in response to a price increase. When the price of insurance lessens, symmetrically, we find that “a” decreases. About the fixed cost C, equality (1.7) shows it has a very similar effect on the degree of prevention.

Proposition 2: In the presence of a compulsory insurance, an increase (respectively decrease) in the unit price or in the fixed cost of insurance induces the risk averse individual to increase (respectively decrease) his investment in self-insurance.

2. **Compulsory insurance and self-insurance : the case of (mixed) risk lovers**

We now consider the case of a risk lover who has the opportunity to voluntary invest in self-insurance while a partial insurance coverage is mandatory. The context is absolutely identical to the previous case, except for the utility function U(W) which reports now, a risk-loving behavior (U''(W> 0)). We show that if the risk lover is committed to invest in insurance, he will reconsider his prevention behavior and will invest more in self-insurance. In that sense, we find a complementarity between both types of hedging. We develop both a graphical reasoning and a formal proof.

In the plane (W_1, W_2), figure 1 illustrates the consequences of a partial insurance obligation on the demand for self-insurance from a risk-lover. It shows that a partial compulsory insurance - which is a plague for a risk-loving decision maker – induces him to supplement this coverage by voluntarily investing in self-insurance.

In the plane (W_1, W_2), an indifference curve for a risk averse agent is concave with respect to the origin and its slope, evaluated at point (W_1, W_2) is $-\frac{(1-q)U'(W_1)}{qU'(W_2)}$. Therefore, the slope of any indifference curve at the intersection with the 45° line is equal to $-\frac{(1-q)}{q}$, which is also the slope of the actuarial insurance price line, defined in the plane (W_1, W_2).

We start from an initial situation (point D whose coordinates are (W_0, W_0–x_0))[4] in which the risk loving individual is not interested either by insurance or by prevention. This is expressed by the fact that the indifference curve V (q, D) dominates all hedging opportunities. It is assumed that the individual has access to a self-insurance technology that allows him to preserve a part of his wealth in case of disaster. Graphically, this technology is represented by DB, the curve of transformation of random wealth through the use of self-insurance. The slope of this curve is equal to (-1-x'(a)), as paying one extra unit of self-insurance investment generates a marginal decrease in the loss amounting to -x'(a). We assume that there is a value of "a" below which the marginal return of self-insurance is greater than the marginal return of insurance (which is necessary true if -x '(0)> 1/q)[5].

[4] At point D, the level of self-insurance is zero; a = 0 and x (0) = x_0 is the maximum possible loss in the absence of any prevention.

[5] Without this assumption, prevention would be meaningless.

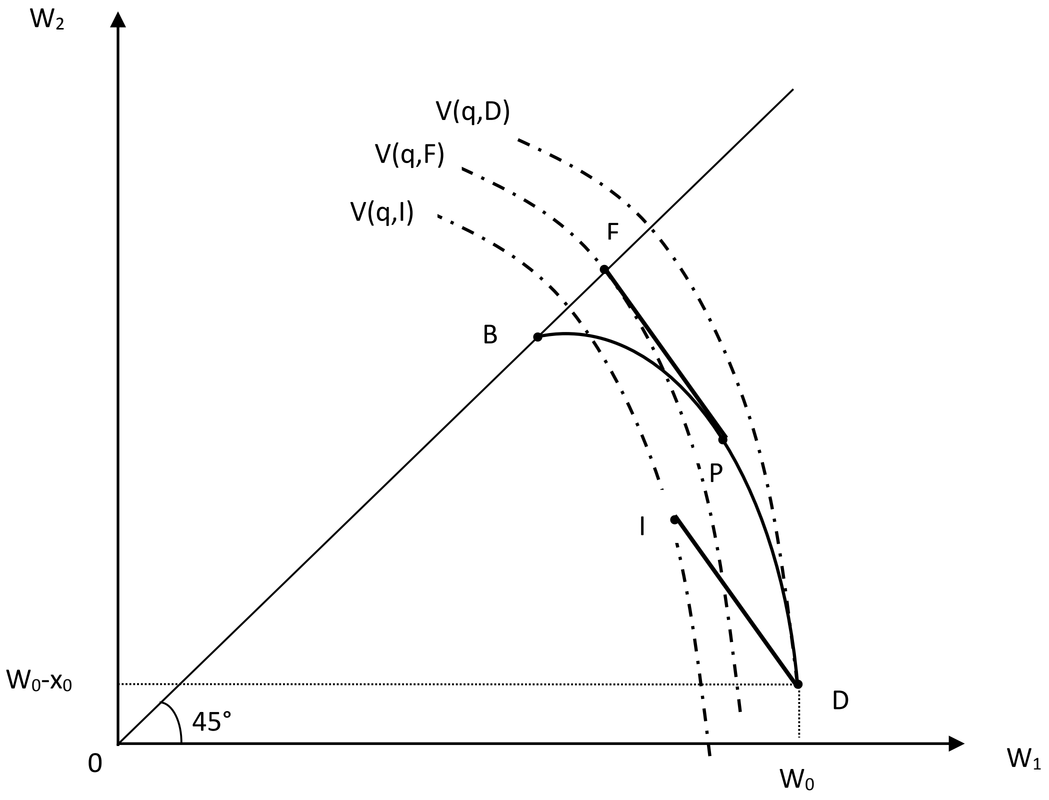

Figure 1: compulsory insurance induces a risk lover to self-insure

With regard to the partial insurance coverage, it is assumed for simplicity that its price is actuarial. It therefore requires a shift from point D to point I, which generates a loss of utility for the risk lover (illustrated by the shift to indifference curve V(q, I)). Then, it is optimal to invest in self-insurance. This investment in self-insurance leads from point D to point P, the point of tangency between DB curve and the insurance line FP. Compulsory insurance (line segments PF and DI are identical) complements the coverage until the full insurance point F.

In the example of Figure 1, it is assumed that the mandatory insurance level is set to generate a comprehensive insurance, for which there is equality between marginal returns of insurance and prevention ($-x'(a^*) = 1/q$). Obviously, the fact that prevention is taken at the point of tangency P between curve DB and insurance line is related to the degree of concavity of indifference curves and the fact that the marginal return of self-selection be sufficiently decreasing. It is therefore quite possible that another level of prevention emerges; likewise, the global coverage depends on the extent of the compulsory insurance coverage and may correspond to a situation of over-insurance or partial insurance (point F above or below the 45° line).

To understand the effect we graphically identified - a partial compulsory insurance encourages the risk lover to invest more in prevention - we start from equation (1.2) which that allowed us to identify the marginal cost and marginal benefit of self-insurance[6]:

$$\frac{\partial \mathrm{EU}}{\partial \mathrm{a}} = -\left\{(1-q)U'\left(W_0 - p\overline{I} - a\right) + qU'\left(W_0 - p\overline{I} - a - x(a) + \overline{I}\right)\right\} + \left\{-x'(a)qU'\left(W_0 - p\overline{I} - a - x(a) + \overline{I}\right)\right\} \quad (1.8)$$

Regarding the marginal benefit (*MB* = -x'(a) qU'(W_2)), as U''(W) is positive, it is clear that an increase in compulsory insurance generates its appreciation since (1-p) is positive.

Regarding the marginal cost (*MC* = (1-q) U'(W1)} + qU'(W2)), the impact is more ambiguous since an increase in the insurance coverage reduces the wealth of state 1 while it increases that of state 2. Deriving the marginal cost with respect to $\overline{I}$ we obtain:

$$\frac{\partial C_m}{\partial \overline{I}} = -p(1-q)U''\left(W_0 - p\overline{I} - a\right) + (1-p)qU''\left(W_0 - p\overline{I} - a - x(a) + \overline{I}\right) \quad (1.9)$$

For p ≥ q and for partial insurance ($W_1 > W_2$), this expression is unambiguously negative if u'''(W)> 0. This assumption on the third derivative of the utility characterizes a precautionary behavior and is fully justified in the case of (mixed) risk lovers, as shown by Crainich, Eeckhoudt and Trannoy (2013). Thus, the marginal cost of self-insurance diminishes with the degree of the compulsory coverage[7]. We deduce the following proposition:

[6] It is assumed that this condition characterizes a maximum, which requires additional assumptions about the behavior of self-insurance. Graphically (see Figure 1), we obtain a maximum if the DB curve is more concave than the indifference curves of the risk-loving agent. This is far from unrealistic since it is sufficient for this that the marginal return of the 1st unit of prevention be high enough and decreases thereafter.

[7] If there is over-insurance, by symmetry, the marginal cost of prevention is increasing and the total effect of an increase in the insurance coverage on the marginal perception of prevention is not clear.

Proposition 3: Whatever the initial level of self-insurance, an increase in the (partial) coverage of the compulsory insurance induces the risk lover to invest more in prevention because it enhances the marginal benefit of self-insurance and reduces its marginal cost.

Returning to our main issue – compulsory insurance and secondary prevention – the lessons from proposition 3 are straightforward.

Starting from a situation where the risk lover is already investing in prevention, it is clear that the introduction of compulsory insurance will lead him to revise his judgment and increase the level of self-insurance.

By contrast, if the risk lover, in the absence of insurance, refuses to invest in prevention, although early self-insurance units are more productive than the actuarial insurance ($-x'(0) > 1/q$), there is a threshold for compulsory coverage from which he will invest in self-insurance. For proof, just evaluate equation (1.8) when a = 0 and without any insurance. In this case, as he is refusing to invest in prevention, the individual perceives, for the first self-insurance unit, a marginal cost above the marginal benefit:

$$\left\{(1-q)U'\left(W_0\right)+qU'\left(W_0-x(0)\right)\right\}>\left\{-x'(0)qU'\left(W_0-x(0)\right)\right\}$$

By Proposition 3, we know that the introduction of compulsory insurance tends to reduce the marginal cost (left term) and to increase the marginal benefit (right term). At the other extreme, when the compulsory insurance is comprehensive ($\overline{I}$ = x (0)) and always for a = 0, the comparison of the marginal cost and benefit leads to the following inequality:

$$\left\{U'\left(W_0-px(0)\right)\right\}<\left\{-x'(0)qU'\left(W_0-px(0)\right)\right\}$$

Then, the marginal benefit of the 1st unit of self-insurance is positive, as it was assumed that $-x'(0) > 1/q$. Therefore, given the monotonous variations - and in opposite direction - of *MC* and *MB*, there necessarily exists, between full risk retention and full coverage, a coverage rate at which the use of self-insurance becomes profitable to the risk loving agent. These results are summarized in the following proposition:

Proposition 4:

Imposing a partial compulsory insurance to a risk loving individual induces himself:

- Either to increase an initially pre-existing self-insurance investment;
- Or to invest in an initially non-existent self-insurance activity, provided that the mandatory coverage ratio exceeds a certain threshold.

3. **Conclusion:**

The coexistence of risk lovers and risk averters may have surprising implications for public policies. Dealing with secondary prevention (self-insurance), public policies are generally based on the idea that insurance and self-insurance are substitutes. In the case of Health Insurance, and following this prediction, the generosity of the public (or/and compulsory) insurance coverage could be responsible for a decrease in self-insurance investments and correlatively an increase in risk exposure. The presence of deductibles in the French public health insurance system, could be an illustration of such a mechanism: a partial insurance coverage is expected to give some incentives for both types of prevention, self-insurance and self-protection. This prediction no longer holds for risk-lovers since our contribution highlights the fact that compulsory insurance and self-insurance are complementary.

For the whole population, depending on the intensity of the effects and on the proportion of risk lovers versus risk averters, we could observe a global increase in self-insurance as a response to the implementation of a partial compulsory insurance coverage. In that sense, our results mitigate the standard statement that insurance and self-insurance are substitute. To illustrate this, suppose we have a competitive market for each hedging scheme and two groups of identical individuals in the population: risk averters and risk lovers. At equilibrium, risk averters will combine optimally both types of risk hedging while risk lovers will invest, at most, in self-insurance depending on its return. Now, suppose a compulsory insurance coverage is imposed and settled precisely at the optimum of the risk averters. Then, while the self-insurance investment will remain the same for this group, it will be enhanced for the group of risk lovers. Globally, the effect will be unambiguous: a compulsory insurance, instead of a voluntary insurance, results in an increase of self-insurance investments in the whole population.

Finally, our analysis brings an unexpected justification for compulsory insurance schemes. If such a regulation enables to overcome asymmetric information, as mentioned by Akerlof (1970) for example, its rightness is generally challenged by its negative incentive effects on prevention. Our contribution mitigates this point of view and underlines that the nature of these incentive effects is risk attitude-dependent. Moreover, a compulsory insurance scheme could, under some circumstances, increase the global level of self-insurance.

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