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On the uselessness of self-insurance clauses ?

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Abstract

An insurer can monitor the policyholder's prevention effort when it is observable ex-post by using a contract clause. The literature on insurance contracts does not explicitly address the role of contract clauses. We examine the role of such clauses in case of self-insurance. Because of the substitutability between insurance and self-insurance, contract clauses focused on self-insurance investments could cause a possible deterrent effect on insurance demand, highlighting their puzzling nature. In a theoretical model, we examine two arguments to overcome the compulsory self-insurance clause paradox: the observability of the self-insurance investment and the role of the self-insurance clause on insurance demand. The fact that self-insurance investments are not observable ex-ante cannot justify the use of a mandatory clause. Neither the demand for insurance nor the demand for prevention is observability-dependent. Therefore, self-insurance clauses are, at best, useless, at worst, counterproductive: when binding, they reduce the size of the insurance market.

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1 Introduction

To manage the risks they face, individuals combine hedging tools such as primary insurance, prevention activities, complementary insurance mechanisms and savings. Moreover, many basic insurance contracts include contract clauses involving devices such as fire alarms, seat belts and fire extinguishers. Insofar as these arrangements may interfere with the demand for insurance, their effects deserve further analysis. In the case of hedging tools designed to reduce the probability of loss (self-protection), contract clauses could be justified on the grounds of asymmetric information. Indeed, Ehrlich and Becker (1972) found that when self-protection is voluntary and observable, insurance and self-protection are complementary: a decrease in the insurance price would result in an increase in both hedging tools. On the contrary, when the level of the self-protection effort is unobservable by the insurer, the authors show that both hedging tools (insurance and self-protection) become substitutes since the insurer is unable to adapt the contract to the self-protection effort. In this case, lowering the insurance premium would have a deterrent effect on the prevention activity. However, Shavell (1979) showed that the observability of the self-protection effort by the insurer, whether implemented ex-ante or ex-post, may improve the overall risk hedging of the policyholder. In particular, it may be advantageous to observe the self-protection effort ex-post (i.e., only after the damage has occurred) whenever observation is costly. Although not explicitly mentioned in the literature on insurance economics, these findings provide the rationale for self-protection clauses in insurance contracting. Such clauses make it possible to monitor the policyholder's behavior without observing ex-ante the prevention effort. Since a contract clause guarantees the compliance to a standard of prevention, it restores, in a sense, the observability of the policyholder's behavior. Therefore, contract clauses make it possible to better link the insurance pricing to the self-protection effort and to restore the complementarity between risk-hedging mechanisms. Self-protection clauses in insurance contracting could therefore improve the well-being of both parties.

Alternatively, as mentioned in Ehrlich and Becker (1972), risk management may rely on investments and activities devoted to loss reduction. Such activities, originally referred to as self-insurance, cover many risk prevention mechanisms, including all the technologies intended to decrease the size of losses such as health screening tests, prudential rules in insurance and banking, etc. This type of prevention also motivates the use of contract clauses. With regard to loss reduction activities and behaviors, the clause puzzle is two-tiered, which makes it even more challenging.

First, when the amount of self-insurance investment is common knowledge, Ehrlich and Becker (1972) show that self-insurance and insurance are substitutes: an increase in the insurance price raises the self-insurance investment and reduces the demand for insurance. Yet, numerous theoretical, empirical and experimental studies have corroborated this substitutability property. For example, Courbage (2001) proves that insurance and self-insurance are still substitutes under the dual theory of choice. Pannequin and Corcos (2010) show that under the Stiglitz insurance monopoly model (Stiglitz, 1977), self-insurance opportunities mitigate the insurer's rent by reducing both its market power and the size of the market. Carson *et al.* (2013) find empirical evidence for the substitution between insurance and self-insurance in the case of homeowner insurance and catastrophic risks. In an experiment, Pannequin *et al.* (2019) observed this substitution although it was lower than predicted by the theory. Therefore, a self-insurance binding clause is likely to undermine the demand for insurance and, from the insurer's point of view, the relevance of such clauses may be disputed.

Second, by itself, a mandatory self-insurance clause could change the nature of the relationship between insurance and self-insurance: following the introduction of such a clause, the insured could experience a real impoverishment, thus enhancing the demand for insurance. Such an effect is likely to mitigate the fundamental substitutability between insurance and self-insurance. Moreover, as for the self-protection case, the justification for the self-insurance clauses could stem from moral hazard considerations due to asymmetric information. By inducing the self-insurance investment, self-insurance clauses could make it possible to set up fairer pricing accounting for the prevention efforts of policyholders. So far, the interplay between insurance and self-insurance when the self-insurance investment is hidden from the insurer has not been examined.

In this paper, we precisely study to what extent the non-observability argument can be translated into compulsory self-insurance clauses. Relying on the comparison between the situations of unobservability and observability ex-ante or ex-post, our theoretical results show that it is not possible, from the insurer's point of view, to justify the use of a self-insurance clause since the demand for insurance is not observability-dependent. While the presence of binding self-insurance clauses induces the insured to reduce his or her insurance deductible, the reduction of the insurance market share is real and the clause remains a puzzle.

The remainder of the paper is structured as follows. Section 2 examines the effect of compulsory self-insurance clauses on optimal self-insurance and insurance decisions under observability of the self-insurance investment by the insurer. Section 3 focuses on this impact in the context of unobservability of the self-insurance investment. Section 4 discusses the results and provides a conclusion.

2 The effect of a self-insurance clause on insurance and self-insurance under observability

This section examines the effect of a mandatory self-insurance clause on optimal self-insurance and insurance decisions, first, presenting the case without a self-insurance clause and, second, the one with a contract clause. For this purpose, we use a simple model of insurance and self-insurance decisions under observability of the self-insurance investment by the insurer.

2.1 Optimal hedging without self-insurance clause

Consider a decision-maker facing a probability q of losing a portion x of the initial wealth W_0. The final wealth would thus be W_0 if no loss occurs, or $W_0 - x$ in the case of loss. In order to reduce the risk exposure, a decision-maker can invest in a self-insurance technology a^o (the exponent o stands for the observability context). Assuming that the amount of the loss, x, is a decreasing function of the amount invested in self-insurance a, we have: $x = x(a^o)$, $x'(a^o) < -1$. Since the self-insurance cost is assumed to be linear, this inequality reflects the fact that the marginal return of self-insurance $(-x'(a^o))$ must exceed its marginal cost, fixed to be 1. Moreover, we assume that the returns on self-insurance are decreasing (*i.e.*, $x''(a^o) > 0$). The decision-maker's preferences are characterized by a vNM utility function $U(W)$, which is strictly increasing and concave ($U'(W) > 0$, $U''(W) < 0$). In addition, a risk-neutral insurer observes the self-insurance investment and proposes an insurance coverage.

Assuming a deductible contract, the insurer specifies the unit insurance price p, while the decision-maker chooses the deductible F^o. Therefore, the insurance premium can be written as: $P^o = pI^o$ where $I^o = x(a^o) - F^o$ stands for the indemnity[1].

Thus, the decision-maker maximizes the following expected utility:

$$\max_{(F^o, a^o)} EU(W^o) = (1-q)U(W_1^o) + qU(W_2^o) \tag{1}$$

where $W_1^o = W_0 - p(x(a^o) - F^o) - a^o$ is the final wealth with no loss, and $W_2^o = W_0 - p(x(a^o) - F^o) - a^o - F^o$ is the final wealth when a loss occurs.

The optimal self-insurance, a^{o*} and insurance, F^{o*} decisions are defined by the following first-order conditions:

$$\begin{aligned} p[(1-q)U'(W_1^{o*}) + qU'(W_2^{o*})] &= qU'(W_2^{o*}) && (2) \\ (1-q)U'(W_1^{o*}) + qU'(W_2^{o*}) &= -x'(a^{o*})p[(1-q)U'(W_1^{o*}) + qU'(W_2^{o*})] && (3) \end{aligned}$$

The second-order conditions can be easily checked. At the optimum, conditions (2) and (3) show that the marginal cost of each mechanism (LHS) is equal to its marginal benefit (RHS). Using these conditions, we easily obtain the following equality:

$$-x'(a^{o*}) = \frac{1}{p} \tag{4}$$

Therefore, at equilibrium, the marginal return of self-insurance equalizes the marginal return of insurance. The unit price of insurance then indirectly settles the self-insurance investment chosen by the decision-maker who sets his or her level of self-insurance at the point that equalizes marginal returns, and complements it by buying some insurance coverage for the residual risk. From condition (4), we can easily verify the substitutability property between insurance and self-insurance obtained by Ehrlich and Becker (1972) when the self-insurance investment is observable. An increase in the unit price of insurance p results in a decline of $-x'(a)$, which in turn leads to a rise in a. Consequently, when self-insurance is observable, insurance and self-insurance are substitutes.

2.2 Optimal hedging with self-insurance clause

We now consider $\overline{a}$ as the minimum level of self-insurance required by the contract clause. Compared to the optimal level a^{o*}, the clause may be binding ($\overline{a} > a^{o*}$) or not ($\overline{a} \leq a^{o*}$). However, since the decision-maker may also decide on a voluntary investment in self-insurance, denoted as Δa^{ob}, where the exponent b stands for binding, in addition to the level imposed by the clause $\overline{a}$, only the study of a binding clause is relevant. Indeed, the non-binding situation boils down to the previous first-best optimum. When the self-insurance investment is observable by the insurer and the clause is binding where $\overline{a} > a^{o*}$, the insurer anticipates the loss $x(\overline{a} + \Delta a^{ob})$. The compensation is then $I^{ob} = x(\overline{a} + \Delta a^{ob}) - F^{ob}$ and the premium is written as $P^{ob} = p(x(\overline{a} + \Delta a^{ob}) - F^{ob})$.

[1]Similarly, we could base our modeling on a coinsurance contract $I^o = cx(a^o)$, where c denotes the coinsurance rate ($0 \leq c \leq 1$). This would strictly lead to the same results. We chose the deductible contract since the optimality of this contract is a very robust result in the literature on insurance demand.

In this context, the decision-maker's program is as follows:

$$\begin{aligned} \max_{(F^{ob},\Delta a^{ob})} \quad & EU(W^{ob}) = (1-q)U(W_1^{ob}) + qU(W_2^{ob}) \\ \text{subject to} \quad & \overline{a} + \Delta a^{ob} \geq \overline{a} \end{aligned} \tag{5}$$

with $W_1^{ob} = W_0 - p(x(\overline{a}+\Delta a^{ob}) - F^{ob}) - \overline{a} - \Delta a^{ob}$, and $W_2^{ob} = W_0 - p(x(\overline{a}+\Delta a^{ob}) - F^{ob}) - \overline{a} - \Delta a^{ob} - x(\overline{a}+\Delta a^{ob}) + x(\overline{a}+\Delta a^{ob}) - F^{ob}$.

Proposition 1. *Under observability of self-insurance investments, a binding contract clause induces the decision-maker to invest the minimum level of self-insurance required by the clause while, compared with the no clause situation, the demand for insurance decreases ($I^{ob*} < I^{o*}$) although the deductible diminishes ($F^{ob*} < F^{o*}$).*

Proof. First, we show that it is optimal for the decision-maker to invest the minimum level of self-insurance required by the binding clause. Since $\overline{a} > a^{o*}$, and $-x'(a^{o*}) = \dfrac{1}{p}$, we infer that $-x'(\overline{a}+\Delta a^{ob}) < \frac{1}{p}$ and any increase in $\overline{a}$ or Δa^{ob} would induce a wealth decrease. At this level of self-insurance, the only effect of a marginal change in $\overline{a}$ or a^{ob} is to reduce each final wealth by $-px'(\overline{a}+\Delta a^{ob}) - 1$. As a result, when $\overline{a} \geq a^{o*}$, the decision-maker chooses a self-insurance investment equal to $\overline{a}$ and no additional investment in self-insurance ($\Delta a^{ob*} = 0$).

The optimal level of insurance F^{ob*} is defined by the following first-order condition evaluated at $\Delta a^{ob*} = 0$:

$$\frac{p(1-q)}{(1-p)q} = \frac{U'(W^{ob}_{2|\Delta a^{ob}=0})}{U'(W^{ob}_{1|\Delta a^{ob}=0})} = \frac{U'(W_0 - p(x(\overline{a}) - F^{ob}) - \overline{a} - F^{ob})}{U'(W_0 - p(x(\overline{a}) - F^{ob}) - \overline{a})} \tag{6}$$

In order to characterize the two situations - the no clause case and the binding clause case - we use conditions (3) and (6). Given that the ratio of marginal utilities is equal to $\frac{p(1-q)}{(1-p)q}$ in both cases, we obtain the following equalities:

$$\frac{p(1-q)}{(1-p)q} = \frac{U'(W_0 - p(x(a^{o*}) - F^{o*}) - a^{o*} - F^{o*})}{U'(W_0 - p(x(a^{o*}) - F^{o*}) - a^{o*})} = \frac{U'(W_0 - p(x(\overline{a}) - F^{ob*}) - \overline{a} - F^{ob*})}{U'(W_0 - p(x(\overline{a}) - F^{ob*}) - \overline{a})} \tag{7}$$

Using condition (7), we show that $F^{ob*} < F^{o*}$. With $\overline{a} > a^{o*}$, the decision-maker is worse off since it is inefficient to over-invest and $px(\overline{a}) + \overline{a} > px(a^{o*}) + a^{o*}$. If we assume that $F^{ob*} = F^{o*}$, under the DARA (Decreasing Absolute Risk Aversion) standard assumption, the numerator of the RHS ratio increases relatively more than the denominator, and the optimality condition is no longer fulfilled. To restore optimality, it is necessary to reduce the deductible in order to increase (resp. decrease) the wealth of the numerator (resp. denominator), so that $F^{ob*} < F^{o*}$. Finally, we show that the presence of a binding contract clause on self-insurance undermines the demand for insurance. To illustrate this result, we rewrite condition (7) knowing that $I^{o*} = x(a^{o*}) - F^{o*}$ and $I^{ob*} = x(a^{ob*}) - F^{ob*}$:

$$\frac{U'(W_0 - pI^{o*} - a^{o*} - x(a^{o*}) + I^{o*})}{U'(W_0 - pI^{o*} - a^{o*})} = \frac{U'(W_0 - pI^{ob*} - \overline{a} - x(\overline{a}) + I^{ob*})}{U'(W_0 - pI^{ob*} - \overline{a})} \tag{8}$$

It becomes obvious that with $\overline{a} > a^{o*}$, the only way to respect the optimality condition is to make sure that $I^{ob*} < I^{o*}$. Ceteris paribus, enforcing $\overline{a} > a^{o*}$ through a contract clause decreases the numerator (since when $\overline{a} + x(\overline{a}) < a^{o*} + x(a^{o*})$, the wealth increases), while it increases the marginal utility of the denominator. It is therefore necessary to lower the indemnity to compensate for the self-insurance increase. Therefore, $I^{ob*} < I^{o*}$. □

The use of contract clauses to monitor the loss reduction behavior of policyholders does not modify the nature of the relationship between insurance and self-insurance. If a binding self-insurance clause enforces a higher level of prevention, the policyholder reduces his or her insurance coverage. The substitutability property still holds.

3 The effect of a self-insurance clause on insurance and self-insurance with unobservable self-insurance

In this section, we assume that the self-insurance investment, or the technology implemented by the policyholder, cannot be directly observed by the insurer. In this context, we examine whether a self-insurance clause can be justified. When self-insurance is not observable ex-ante, or costly to observe ex-ante, a contract clause allows a perfect monitoring of the loss reduction behavior of policyholders. The self-insurance effort is only observed if a claim occurs, but the policyholder has to comply with the contract clause to avoid the nullity of the contract. First, when the insurer cannot observe the decision-maker's self-insurance choice, (s)he has to somewhat anticipate this level so as to design the insurance pricing.

3.1 Optimal hedging without self-insurance clause

When the insurer cannot observe ($\overline{o}$) the decision-maker's self-insurance, we assume that (s)he anticipates a self-insurance investment $\hat{a}^{\overline{o}}$ such that: $0 \leq \hat{a}^{\overline{o}} \leq a^{max}$, where $\hat{a}^{\overline{o}} = 0$ corresponds to the minimal level of prevention[2] and a^{max} to the most expensive investment available on the market. The compensation is then $I^{\overline{o}} = x(\hat{a}^{\overline{o}}) - F^{\overline{o}}$. The decision-maker maximizes the following expected utility:

$$\max_{(F^{\overline{o}}, a^{\overline{o}})} EU(W^{\overline{o}}) = (1-q)U(W_1^{\overline{o}}) + qU(W_2^{\overline{o}}) \tag{9}$$

with $W_1^{\overline{o}} = W_0 - p(x(\hat{a}^{\overline{o}}) - F^{\overline{o}}) - a^{\overline{o}}$, and $W_2^{\overline{o}} = W_0 - p(x(\hat{a}^{\overline{o}}) - F^{\overline{o}}) - a^{\overline{o}} - x(a^{\overline{o}}) + x(\hat{a}^{\overline{o}}) - F^{\overline{o}}$.

The optimal choices are described by the following first-order conditions:

$$p[(1-q)U'(W_1^{\overline{o}*}) + qU'(W_2^{\overline{o}*})] = qU'(W_2^{\overline{o}*}) \tag{10}$$
$$(1-q)U'(W_1^{\overline{o}*}) + qU'(W_2^{\overline{o}*}) = -x'(a^{\overline{o}*})qU'(W_2^{\overline{o}*}) \tag{11}$$

The second-order conditions are satisfied. Taking the ratio of conditions (10) and (11) and rearranging the terms, we find the same fundamental result. A rational agent invests in self-insurance in order to equalize the marginal returns of insurance and self-insurance as follows:

$$-x'(a^{\overline{o}*}) = \frac{1}{p} \tag{12}$$

[2]This can also correspond to a normalization at zero of the previous observed investment since the insurer does not know if the decision-maker will exceed this level during the period.

Proposition 2. *When both risk-hedging tools are simultaneously available to the decision-maker, the optimal levels of self-insurance and insurance are the same whether self-insurance investment is observable or not by the insurer. Although the accuracy of the insurer's foresights about self-insurance behavior may influence the extent of the insurance coverage, the decision-maker adjusts the level of the deductible to reach the same optimum, regardless of the anticipation errors of the insurer.*

Proof. For the self-insurance investment, it can be immediately observed that conditions (4) and (12) are identical. In addition, this equality of the self-insurance investments induces the equality of insurance demands. Indeed, since $a^{\overline{o}*} = a^{o*}$, conditions (2) and (3) on the one hand, and (10) and (11) on the other hand, lead to:

$$-x'(a^{\overline{o}*}) = -x'(a^{o*}) \Rightarrow \frac{(1-q)U'(W_1^{\overline{o}*})}{qU'(W_2^{\overline{o}*})} + 1 = \frac{(1-q)U'(W_1^{o*})}{qU'(W_2^{o*})} + 1 \tag{13}$$

To be verified, condition (13) requires that $x(\hat{a}^{\overline{o}}) - F^{\overline{o}} = x(a^{o*}) - F^{o}$. The RHS of this condition is fixed due to first-order conditions under observability, so that the equality only depends on the insurer's anticipations and on the level of deductible selected by the decision-maker. Rewriting the equality of the insurance coverage levels leads to: $F^{\overline{o}*} = [x(\hat{a}^{\overline{o}}) - x(a^{o*})] + F^{o*}$. Then:

- If the insurer perfectly anticipates the level of self-insurance investment $\hat{a}^{\overline{o}} = a^{o*}$, the deductibles are identical whether the investment is observable or not ($F^{\overline{o}*} = F^{o*}$) and the optimums are also identical.

- If $\hat{a}^{\overline{o}} < a^{o*}$, the insurer underestimates the real self-insurance investment and then proposes a contract in which the value to insure is higher than the one under observability: $x(\hat{a}^{\overline{o}}) > x(a^{o*})$. The reaction of the decision-maker is to adopt a higher level of deductible than under observability ($F^{\overline{o}*} > F^{o*}$). However, this reaction has no effect on the optimum. At the extreme, this optimum would also be reached with a maximum myopia of the insurer ($\hat{a}^{\overline{o}} = 0$).

- If $\hat{a}^{\overline{o}} > a^{o*}$, then the decision-maker reduces the deductible compared to the level of deductible under observability ($F^{\overline{o}*} < F^{o*}$). Such a situation may lead to over-insurance in which optimality requires negative deductible. Indeed, if the insurer strongly overestimates the self-insurance investment $x(\hat{a}^{\overline{o}}) \ll x(a^{o*})$, then $F^{\overline{o}*} = [x(\hat{a}^{\overline{o}}) - (a^{o*})] + F^{o*} < 0$. In particular, with an actuarial price ($p = q$), we know that full insurance is optimal. Consequently, under observability, we would have: $F^{o*} = 0$, and since $\hat{a}^{\overline{o}} > a^{o*}$, any forecast error would lead to an over-insurance situation ($F^{\overline{o}*} < 0$).

□

Remark that since condition (12) is identical to (4), it is trivial that the substitutability property between insurance and self-insurance remains true when the self-insurance investment is unobservable.

3.2 Optimal hedging with self-insurance clause

The insurer is not able to observe ex-ante ($\overline{o}$) the self-insurance investment of the insured, but imposes a self-insurance clause requiring a minimum level of self-insurance $\overline{a}$. We assume that the clause is compulsory and binding in the sense that if the decision-maker does not implement the level of self-insurance required by the clause, (s)he does not receive any insurance indemnity when damage occurs. In the case of a claim, an expert observes the compliance to the contract clause. In this case, the insurer considers that the loss is equal to $x(\overline{a})$ to define insurance compensation and premium. Only the binding clause is examined since the decision-maker can voluntarily complement a non-binding one by a greater investment in self-insurance activity. Any additional investment in self-insurance is considered as the decision-maker's private information by the insurer ($a^{\overline{o}b} \geq 0$). Consequently, the effective loss is a function of the cumulated investments in self-insurance $x(\overline{a} + a^{\overline{o}b})$. In this context, the compensation is $I = x(\overline{a}) - F^{\overline{o}b}$ and the premium is written as $P = p(x(\overline{a}) - F^{\overline{o}b})$. The objective function is then:

$$\max_{(F^{\overline{o}b}, a^{\overline{o}b})} EU(W^{\overline{o}b}) = (1-q)U(W_1^{\overline{o}b}) + qU(W_2^{\overline{o}b}) \tag{14}$$

with $W_1^{\overline{o}b} = W_0 - p(x(\overline{a}) - F^{\overline{o}b}) - \overline{a} - a^{\overline{o}b}$ and, $W_2^{\overline{o}b} = W_0 - p(x(\overline{a}) - F^{\overline{o}b}) - \overline{a} - a^{\overline{o}b} - x(\overline{a} + a^{\overline{o}b}) + x(\overline{a}) - F^{\overline{o}b}$.

Proposition 3. *Under observability ex-post, a binding self-insurance clause induces the decision-maker to invest the minimum level of self-insurance required by the clause, while the demand for insurance exhibits the same pattern as in the observability case: the demand for insurance decreases although the deductible decreases.*

Proof. For self-insurance, the proof of Proposition 3 follows the same reasoning as the one for Proposition 1. The optimal level of insurance $F^{\overline{o}b*}$ is defined by the following first-order condition evaluated at $a^{\overline{o}b*} = 0$:

$$\frac{p(1-q)}{(1-p)q} = \frac{U'(W^{\overline{o}b}_{2|a^{\overline{o}b}=0})}{U'(W^{\overline{o}b}_{1|a^{\overline{o}b}=0})} = \frac{U'(W_0 - p(x(\overline{a}) - F^{\overline{o}b}) - \overline{a} - F^{\overline{o}b})}{U'(W_0 - p(x(\overline{a}) - F^{\overline{o}b}) - \overline{a})} \tag{15}$$

We compare this condition (15) with condition (6). We can immediately see that condition (6) evaluated for $a = \overline{a}$ is identical to condition (15). □

4 Discussion and Conclusion

An intuitive justification for the presence of self-insurance clauses in insurance contracts that motivated this work was that a self-insurance clause could compensate for the ex-ante unobservability of the prevention effort. A contractual clause has the power to enforce a minimum level of self-insurance without any prior control over the policyholder's behavior. It therefore seems natural to resort to this contractual mechanism whenever the insurer is not able to directly infer the self-insurance behavior of policyholders. If the loss reduction effort is not observable ex-ante, or costly to observe, a contract clause - relying on ex-post observability - may induce the insured to make a target investment.

In this paper, we show that whether the self-insurance investment is observable or not, the optimal self-insurance level is the same. The respective involvements of insurance and self-insurance in risk hedging are not influenced by the ability of an insurer to observe the self-insurance effort. In some way, this suggests that the best policy for an insurer when the self-insurance behavior is not freely observable ex-ante is to offer a large menu of contracts to allow the insured to choose the level of compensation (s)he wants. At the same time, it is inefficient for the insurer to invest in any policy designed to improve information about self-insurance behavior.

These theoretical results therefore leave the puzzle unsolved: while a self-insurance clause seems to be a standard tool of insurance contracting, we find no advantage for insurers to use it. Since the perfect observability of the self-insurance investment does not enhance the social welfare, there is no additional rent to appropriate. Even worse, from the insurer's point of view, a self-insurance clause is counterproductive since it may reduce the size of the insurance market.

Another interesting result of this article emerges regardless of the observability context. It suggests that when considering both insurance and self-insurance demands, risk aversion only impacts the insurance demand since the self-insurance demand is not risk-aversion-dependent. Dionne and Eeckhoudt (1985) found that self-insurance demand increases with risk aversion. Contrary to this result, we show that, when combined with insurance opportunities, the demand for self-insurance does not depend on the individuals' risk-aversion coefficient. On the basis of the comparison of conditions (2) and (4) under observable self-insurance (resp. (10) and (12) under unobservable self-insurance), the optimal level of insurance, defined by condition (2) (resp. (10)) depends on risk aversion, whereas, on the contrary, condition (4) (resp. (12)) defining the optimal level of self-insurance is independent of risk aversion. This result is in line with Pannequin *et al.* (2019).

To conclude, we demonstrate the existence of a puzzle that does not depend on the observability (or not) of the self-insurance investment. Solving this puzzle would then require further investigations.

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