Asymmetric Information in Insurance: Some Testable Implications[*]

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Abstract

Several recent papers on empirical contract theory and insurance test for a positive correlation between coverage and ex post risk, as predicted by standard models of pure adverse selection or pure moral hazard. However, these models rely on strong and empirically implausible assumptions (such as one dimensionality, identical preferences, etc.). We provide a testable implication of asymmetric information that is valid in a very general set-up. We then show that the positive correlation property can in fact be extended to many competitive insurance markets, and to cases where risk aversion is public.

1 Introduction

While the economics of insurance under asymmetric information dates back to the 1970s', only recently has there been extensive testing of its theoretical

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conclusions. A standard problem facing any empirical work on the topic is that the robustness of the testable predictions derived by existing theory is often unclear. Theoretical models in asymmetric information typically use oversimplified frameworks, that can hardly be directly transposed to real life situations. To give but one example, Rothschild-Stiglitz's (1976) celebrated model of competition under adverse selection in insurance assumes that accident probabilities are exogenous (which rules out moral hazard), that only one level of loss is possible, and more strinkingly that agents have identical preferences which are moreoever perfectly known to the insurer. The theoretical justification of these restrictions is straightforward: analyzing a model of 'pure', one-dimensional adverse selection is an indispensable first step. But their empirical relevance is dubious, to say the least. In 'real life' insurance, moral hazard can hardly be discarded a priori, and interact with adverse selection in a non-trivial way, as precaution depends on risk and preferences[1]; losses are continuous variables, often ranging from small amounts to hundreds of thousands of dollars; last but not least, preference heterogeneity is paramount and largely unobserved.

All this clearly suggests that an indispensable prerequisite for any empirical work is the *theoretical* derivation of *robust* predictions that can be taken to data. This is the goal of the present paper. Specifically, we concentrate on a central property of asymmetric information models in insurance, on which recent empirical works have largely focussed[2]. The property states that under both moral hazard and adverse selection, one should observe of a *positive correlation* (conditional on observables) between risk and coverage: if different insurance contracts are actually sold to observationally identical

[1] See Chassagnon-Chiappori (1997)), de Meza-Webb (2001), Jullien-Salanié-Salanié (2001).

[2] See for instance Chiappori-Salanié (2000) and the references in Chiappori (2000).

agents, then the frequency of accidents among the subscribers of a contract should increase with the coverage it offers.[3] In the Rothschild-Stiglitz (1976) model, where riskiness is an exogenous and unobservable characteristic of agents, the correlation stems from the fact that 'high risk' agents are ready to pay more than 'low risk' ones for additional coverage, and will therefore choose contracts with higher coverage. Under pure moral hazard, as in Arnott-Stiglitz (1988), an opposite causality generates the same correlation: an agent who, for any unspecified (and exogenous) reason, switches to a contract with greater coverage makes less effort and thus becomes riskier.

Popular as this prediction may be, its robustness is, in principle, not guaranteed; whether it would remain valid in the presence of moral hazard, heterogeneous preferences or multiple level of losses has not (yet) been demonstrated.[4] Our paper is devoted to a *theoretical* analysis of this issue. We show that the original intuition derived from Rothschild-Stiglitz extends to more general models, as already conjectured by Chiappori and Salanié (2000), although its scope and robustness varies with the type of competition at stake. Specifically, we extend the property in three directions. First, using a revealed preferences argument, we derive a weaker version of the correlation argument that is robust to any assumption on the nature of competition, and can furthermore be tested from data on reimbursements and distributions of claims alone. Secondly, we consider the case of competitive markets, and show that asymmetric information (adverse selection and moral

[3] While this paper focusses on the insurance sector, similar remarks could be made concerning empirical studies of asymmetric information in other activities. For example, one of the first papers to test the Stiglitz-Weiss(1981) theory is Ausubel (1999), in the context of credit cards. Ausubel finds convincing evidence of adverse selection, through a similar test of correlation: clients accepting higher credit rates are more likely to default. The methodology developed here could as well be useful in other cases.

[4] Note, in particular, that in a general context, the frequency of accidents is only one indicator of riskiness, as the size of losses also matters; therefore the notion of positive correlation between risk and coverage is less straightforward.

hazard) indeed implies a positive correlation between risk and coverage, for suitably defined such notions. This result is a direct extension of Rothschild-Stiglitz's initial idea to a very general framework (entailing heterogeneous preferences, multiple level of losses, multidimensional adverse selection plus possibly moral hazard, and even non expected utility). Thirdly, we study the case of imperfect competition, and we underline the key role of the agent's risk-aversion. If it is public information, then some form of positive correlation is verified. In particular, with only one level of loss and expected utility, the highest coverage contract must exhibit the highest frequency of accident. Conversely, if risk-aversion is private information, the property does not necessarily hold: this was shown in Jullien-Salanié-Salanié (2001). The aversion to risk is thus a key parameter whose informational status drive the testable implications of simple models in the presence of market power.

Section 1 builds a general model of insurance under asymmetric information, that allows for non-expected utility preferences, multiple loss, adverse selection on risk and preferences, and moral hazard on risk. In Section 2, we apply a revealed preference argument to obtain a first testable implication, that relates the premium differential to expected indemnities. Section 3 analyses the stronger version of the correlation property; we show that it holds both when competition drives profits to zero and when risk aversion is public information. Section 4 concludes.

2 The General Framework

Suppose that we observe a population of insurance policy holders, their insurance policies and their insurance claims. Typically an insurance contract specifies an indemnity $R(L) \geq 0$ for every possible claim level $L \geq 0$ and a premium P paid up-front. By definition, $R(0) = 0$ and we set $L = 0$ in the case of no claim. For each contract the indemnity function is fixed, but we allow the premium to vary with the observable characteristics of the insured. Let X be the vector of individual characteristics that are used by the insurer to determine the premia on various contracts. In what follows, we assume that the econometrician observes X (from the insurer's files). Based on the data on observed claims and premia, the econometrician can estimate premia $P_i(X)$ and distributions of claims $F_i(L \mid X)$ conditional on X for each contract C_i. Our goal is to derive predictions that can be tested on such data.

For this, let us introduce a model allowing for both adverse selection and moral hazard. Consider a population of insurance policy holders that is indistinguishable for the insurers, which means that we control for characteristics X, and derive predictions valid for each value of X. >From now on, we omit the variable X, although it should be clear that all the results are conditioned on it. We thus denote P_i and $F_i(L)$ the premium and the empirical distribution of claims for contract C_i within the population of individuals with given characteristics X.

Each agent within this population faces the risk of an accident, equivalent to a monetary loss. Losses are assumed to lie in some compact subset of the non-negative real line, a zero loss corresponding to the case of no accident. Each agent can buy an (exclusive) insurance contract $C = (R(.), P)$. Note that the agent need not always report a loss, if it is associated with no indemnity. This is the case for instance when the loss is smaller than the deductible in the contract. For conciseness we identify claims and losses, but our predictions are valid for reported claims (see section 3.2). Each potential insured is characterized by a (possibly multidimensional) parameter θ, which is his private information. The parameter θ may affect the agent's preferences. Moreover an agent of type θ may secretly choose the distribution of claims F in some subset $\mathcal{F}^\theta$. The set $\mathcal{F}^\theta$ may be a singleton, as in pure adverse selection models, or include more than one choice, as when agents choose prevention efforts in moral hazard models. Within this very general setup, we assume:

1. Each agent's preferences can be represented by a preference ordering over the final distribution of wealth, monotonic with respect to first order stochastic dominance.

2. Agents are risk averse in the sense that they are averse to mean-preserving spreads on wealth.

3. Risk-sharing: the net loss $L - R(L)$ is non-decreasing with L.

These assumptions are very weak. Models of insurance with risk-loving individuals do not seem to be very promising; and contracts for which $R(L)$ increase faster than L exert perverse incentives, since the agent sometimes prefer to make the accident worse.

Under this form, it is clear that the class of models we consider encompasses most existing contributions, including the following works which all assume a Von Neumann Morgenstern utility function $u^\theta(W, F)$:

- *Pure adverse selection* (Rothschild-Stiglitz (1976) or Stiglitz (1977)): here $\mathcal{F}^\theta$ is a singleton. The Von Neumann-Morgenstern utility function u^θ does not depend on F, but it may depend on θ as in the multidimensional model of Lansberger-Meilijson (1999).

- *Moral hazard plus adverse selection on prevention cost* (Chassagnon-Chiappori (1997)): here $u^\theta(W, F) = v(W) - c^\theta(F)$, where v is common to all types of agents.

- *Moral hazard plus adverse selection on risk aversion.* In De Meza-Webb (2001), utility takes the form $u^\theta(W,F) = v^\theta(W) - c(F)$; in Jullien-Salanié-Salanié (2001), $u^\theta(W,F) = v^\theta(W - c(F))$. In both models, c is common to all types of agents, which differ only through their utility of wealth v^θ.

Lastly, it is important to stress what our results do *not* require. Although we allow for a general form of adverse selection (including multidimensional characteristics) plus possibly moral hazard, we do not impose any single-crossing condition. We do not restrict the number of types, nor their distribution. Neither do we assume expected utility maximization; our results hold in a non-expected utility framework as well.

3 A First Testable Implication

Consider different contracts C_1 and C_2 proposed on the market, and bought by some agents in the indistinguishable population. To compare the two contracts we rely on the following simple definition:

Definition 1 *Contract C_2 covers more than contract C_1 if $R_2(L) - R_1(L)$ is non-decreasing.*

A typical example is the case of two straight deductible contracts $R_i(L) = \max\{L - d_i, 0\}$ with $d_2 \leq d_1$. In the case of two events, $L \in \{0, \bar{L}\}$, this amounts to $R_2(\bar{L}) \geq R_1(\bar{L})$.

We first establish a simple but useful revealed preference property.

3.1 A revealed preference argument

To build the test, we rely on the fact that observationally identical individuals choose the two contracts, and in particular some choose the least coverage contract. First notice that as $R_2(L)$ is larger than $R_1(L)$, the premium must be higher for contract $C_2 : P_2 - P_1 > 0$. Risk aversion then allows to strengthen the bound on the premia differential:

Proposition 1 *Assume that agent θ prefers contract C_1 to C_2, and C_2 covers more than C_1. Let F_1^θ be the distribution of1 claims of agent θ under C_1. Then*

$$P_2 - P_1 \geq \int_0^{+\infty} R_2(L)dF_1^\theta(L) - \int_0^{+\infty} R_1(L)dF_1^\theta(L) \tag{1}$$

Thus the risk premium increases with the coverage, when evaluated with the empirical distribution of claims observed for the least coverage contract. The result states that if an agent chooses one contract over another with better coverage, the increase in premium must be sufficient for the expected income of the agent to decrease at unchanged behavior. If this were not the case, a risk neutral agent would prefer C_2 to C_1, and a fortiori a risk-averse agent.

As this result only uses revealed preference, it is very general. For instance, it still holds if there is some compulsory insurance, as it involves only the comparison between two available contracts, conditional on the fact that the agent buys a contract. Also, it does not require perfect competition: the property holds under monopoly or oligopoly as well.

3.2 Testing the Implication

To turn Proposition 1 into a feasible test, we need to the inequality over the set of agents with identical observable characteristics who choose contract C_1. The empirical distribution of claims for contract C_i within this population is $F_i(L) = E\left\{F_i^\theta(L) \mid C_i\right\}$. Then the inequality becomes: if C_2 covers more than C_1, then for all X

$$P_2 - P_1 \geq \int_0^{+\infty} R_2(L)dF_1(L) - \int_0^{+\infty} R_1(L)dF_1(L). \tag{2}$$

Notice first that the empirical distribution of claims depends on the contract in two ways. First the contract affects the level of risk chosen by each insured under moral hazard. Second it affects the distribution of the types θ who chose contract C_i. Notice also that the test requires to have an estimate of the premium that the individuals would have to pay for contract C_2, which depend on the observable characteristics X. Thus the insurer's information on the insured must be known by the econometrician. An exception occurs when the insurer cannot legally discriminate on the basis on some variables (sex, race), which can thus be omitted.

Finally, it is important to show that (2) holds in settings when L is observable only if the insured reports a claim. Indeed, under contract C_1, it is possible that the insured does not declare some accidents L knowing that $R_1(L) = 0$. Nevertheless, and assuming away any declaration costs, the insured could have declared such accidents; denote G_1 the distribution of claims in this case. Note that the insured gets the same payoff under (C_1, F_1) and under (C_1, G_1). Since by assumption he prefers C_1 to C_2, then he must prefer (C_1, G_1) to (C_2, G_1). Therefore (2) must hold at G_1:

$$P_2 - P_1 \geq \int_0^{+\infty} R_2(L)dG_1(L) - \int_0^{+\infty} R_1(L)dG_1(L).$$

Now the right-hand-side is the same if one replaces G_1 by F_1, since these weights only differ at points where $R_1(L) = R_1(0) = 0$. And in the left-hand-side, replacing G_1 by F_1 reduces the expected indemnities, since some claims with $R_2(L) \geq 0$ are not declared anymore. Therefore the inequality remains valid if one replaces G_1 by F_1, as announced.

A first trivial application is when there are only two events $L \in \{0, \bar{L}\}$. Contracts involve a single level of indemnity, so that $R_i(L)$ takes value 0 or $R_i(\bar{L})$. In this case let p_i be the empirical probability of a claim under contract C_i. If contract 2 covers more than contract 1, then $R_2(\bar{L}) > R_1(\bar{L})$, and (2) trivially writes as

$$P_2 - P_1 \geq p_1(R_2(\bar{L}) - R_1(\bar{L})) \tag{3}$$

The results extends as follows to the case of two contracts with straight deductible $d_1 > d_2$, $R_i(L) = \max\{L - d_i, 0\}$. From the empirical data, we can obtain the probability p_i that a positive claim occurs under C_i and the expected claim e_i conditional on a claim occurring. We then obtain $P_2 - p_1(e_1 - d_2) \geq P_1 - p_1(e_1 - d_1)$.

Corollary 2 *Suppose that C_2 and C_1 are two straight deductible contracts, and C_2 covers more than C_1. Let p_i be the probability of a claim under C_i. Then*

$$P_2 - P_1 \geq p_1(d_1 - d_2). \tag{4}$$

4 The Positive Correlation Property

The result in Proposition 1 provides a test that doesn't rely on the market structure, but requires estimating the conditional premia. However, this test does not translate obviously into a correlation structure between risk and coverage, which is the essence of property ($\mathcal{M}$). This is not surprising. In contrast with the previous results, property ($\mathcal{M}$) cannot be expected to hold independently of the market structure or the information structure. We develop below two contexts in which the property indeed holds. For now on, we omit the observable variables X, although it should be clear that all results are conditioned on it. We will denote $F_i(L)$ the empirical distribution of claims observed for contract C_i, for a given value of X.

4.1 Competitive environment

As is well known, the mere definition of a competitive equilibrium under asymmetric information is a difficult task, on which it is fair to say that no general agreement has been reached. For the moment, we only make a mild assumption, namely that competition, whatever its particular form, leads to zero profits. Technically, let $\pi(C_i)$ be the profit the insurer makes on contract C_i. Then in the absence of loading or taxation, but allowing for a cost per contract K, we can write (for a given value of X)

$$\pi(C_i) = P_i - \int_0^{+\infty} R_i(L)dF_i(L) - K.$$

We thus assume the following:

Zero profit assumption : $\pi(C_i) = 0$ *for every contract that is traded.*

The zero profit assumption holds in the Rothschild-Stiglitz model and in fact in most theories of competitive equilibrium that have been proposed in the literature. An exception is the model of cross subsidies of Miyazaki, to which we will come back later. Of course, it needs not hold in non-competitive models such as Stiglitz (1977) or Jullien-Salanié-Salanié (2001).

Under the zero profit assumption, empirical riskiness and coverage are related as follows:

Proposition 3 *Assume that the zero profit assumption holds. If two contracts C_1 and C_2 are bought in equilibrium, and C_2 covers more than C_1,* *then*

$$\int_0^{\infty} R_2(L) dF_2(L) \geq \int_0^{\infty} R_2(L) dF_1(L). \tag{5}$$

Proof: From Proposition 1 we have for each θ that chose C_1 :

$$P_2 - \int_0^{+\infty} R_2(L) dF_1^{\theta}(L) \geq P_1 - \int_0^{+\infty} R_1(L) dF_1^{\theta}(L).$$

Taking the expectation conditional on the choice of C_1, we obtain:

$$P_2 - \int_0^{+\infty} R_2(L) dF_1(L) \geq P_1 - \int_0^{+\infty} R_1(L) dF_1(L).$$

The zero profit assumption gives us

$$P_2 - \int_0^{+\infty} R_2(L) dF_2(L) = P_1 - \int_0^{+\infty} R_1(L) dF_1(L)$$

Substracting these two equations immediately yields the result. ■

The results state that the empirical risk is larger for the highest coverage contract, in the sense that the average indemnity would be smaller with the distribution of claims of the other contract.

Remark: Notice that the result only requires that profit doesn't increase with coverage, $\pi(C_1) \geq \pi(C_2)$. Thus, we can escape from the zero profit condition provided that the least profitable contract covers more.

The general insight can be summarized as follows. First assume that competition leads to actuarially fair contracts and yet our result does not hold: at least two contracts C_1 and C_2 are sold at equilibrium, and C_1 covers less than C_2 but has ex post riskier buyers. Since C_1 has higher ex post risk, its "unit price" (i.e., the ratio of premium to coverage) will be larger. But this leads to a contradiction, as under fair pricing, rational agents will never choose a contract entailing less coverage at a higher unit price.

Testing Proposition 3 only requires observing the insurers' observables X, two contracts, one of which has higher coverage, and being able to estimate the conditional distributions of claims. In particular it doesn't require to know the premiums under the two contracts.

It is easy to derive consequences of this property. First note that a contract with full insurance, if available, must generate larger expected claims than any other contract. Second, in the case of straight deductibles, we obtain that

$$p_2 e_2 - p_1 e_1 \geq (p_2 - p_1) d_2. \tag{6}$$

Thus if contract C_2 leads to a higher probability of a claim, it must also generate larger expected claims.

Of particular theoretical interest is the case in which contracts specify a fixed level of reimbursement for any accident. Then the empirical riskiness must be positively correlated with the coverage, which is the test performed in Chiappori-Salanié (2000).

Corollary 4 *Assume that the zero profit assumption holds and that* $L \in \{0, \bar{L}\}$*. If two contracts* C_1 *and* C_2 *are bought in equilibrium, and* C_2 *covers more than* C_1*, then* $p_1 \leq p_2$*.*

It is easily seen that this corollary also extends if a constant administrative cost of processing a claim is allowed in the definition of profits. In the general case, these costs may however threaten the result in Proposition 3. De Meza-Webb(2001) indeed offers a model in which agents choose between insurance and no insurance. Then costs per claim are only incurred for insured agents;

and this changes the computation of the actuarial premium which allowed us to derive Proposition 3.[5] More generally, one may argue that a contract with higher coverage is also more comprehensive[6], so that costs per claim may be higher. Under general contracts and costs $c_i(L)$ which may differ across contracts, the result in Proposition 3 becomes

$$\int R_2(L)[dF_2(L) - dF_1(L)] \geq \int c_1(L)dF_1(L) - \int c_2(L)dF_2(L)$$

and whether the left-hand-side remains positive now becomes an empirical question. Clearly more information is needed on costs per claim to provide a satisfactory test of this inequality.

Similar phenomenons occur if one takes into account experience rating, taxation of indemnities or premia, or a loading factor. In the case of experience rating, the occurrence of an accident causes an increase in future premia, which can be approximated by a reduction D_i in the indemnity $R_i(L)$; Proposition 1 and 3 then change accordingly. Similarly, any taxation modifies the computation of actuarial premia, and Proposition 3 must be restated.[7] In all these cases, a test of our predictions is still possible, provided some assumptions are made on these newly introduced parameters.

4.2 Expected utility with public risk aversion

Here we assume that the agent has a Von Neumann-Morgenstern utility function $u^\theta(W, F)$. Moreover, his coefficient of absolute risk version is publicly

[5] This point is due to Koufopoulos(2001).

[6] Consider for example automobile insurance, for which the basic contract only covers damages to third parties. Extending the coverage to the damages incurred by the insuree requires estimating these damages. We thank David de Meza and David Webb for this remark.

[7] More generally if the profit writes $P - (1 + \lambda)E\{R\} - K$, the prediction becomes $\int_0^\infty R_2 dF_2 + \lambda \left(\int_0^\infty R_2 dF_2 - \int_0^\infty R_1 dF_1 \right) \geq \int_0^\infty R_2 dF_1$, which can be tested with an estimate of λ. Notice that it implies $\int_0^\infty R_2 dF_2 \geq \int_0^\infty R_1 dF_1$.

known, which implies agents share the same risk-aversion and that it is independent of the distribution F. Under this assumption the utility function is determined up to an affine transformation.

Public risk aversion: *There exists a function* $v(W)$ *such that, for any* θ, *one can write*

$$u^{\theta}(W,F) = a^{\theta}(F)v(W) - c^{\theta}(F)$$

with $a^{\theta}(p) > 0$.

The class of models satisfying this assumption, although restricted, includes the standard models of pure adverse selection à la Stiglitz (1977) and pure moral hazard à la Arnott-Stiglitz (1988), as well as more complex frameworks.

For what follows let us denote

$$\Phi(L, C_1, C_2) = v(-L + R_2(L) - P_2) - v(-L + R_1(L) - P_1)$$

the difference in ex-post utility between the two contracts.

If two contracts C_1 and C_2 are bought in equilibrium by some individuals within the indistinguishable population, revealed preference implies that[8]

$$\int_0^{+\infty} \Phi(L, C_1, C_2) dF_2(L) \geq \int_0^{+\infty} \Phi(L, C_1, C_2) dF_1(L). \tag{7}$$

Notice that for this property, F_i is the distribution of losses. The function Φ is increasing in the range where it is positive, but may not be in the negative range. However combined with (2), it yields some interesting conclusions in cases of interest.

[8] The RHS (resp. LHS) is negative (resp. positive) for each individual buying C_1 (resp. C_2). It then suffices to aggregate over the relevant population.

First, when the contract C_1 and C_2 are straight deductible, Φ is non-decreasing, so that (7) can be considered as a measure of riskiness. However, Φ is endogenous and its precise form depends on the utility function v.

The implication is the most clear for the case of two events, accident and no accident:

Proposition 5 *Assume that risk aversion is public and that $L \in \{0, \bar{L}\}$. If two contracts C_1 and C_2 are bought in equilibrium, and C_2 covers more than C_1, then $p_1 \leq p_2$.*

Proof: From (3), we must have $P_2 > P_1$. For C_2 to be bought it must be that

$$R_2 - P_2 \geq R_1 - P_1$$

>From (7) :

$$(p_2 - p_1)\left(v(-\bar{L} + R_2 - P_2) - v(-\bar{L} + R_1 - P_1) + v(-P_1) - v(-P_2)\right) \geq 0;$$

hence $p_2 \geq p_1$.■

This result was already known in the Rothschild-Stiglitz case. Our contribution here is to highlight the key role played by the assumption of identical risk-aversion. In particular, once agents have chosen their preventive efforts they can be ordered according to their riskiness; and then the assumption guarantees that agents which are *ex-post* riskier indeed prefer contracts with higher coverage.

Hence the positive correlation property is extended to a number of standard cases, encompassing models with adverse selection and moral hazard. It seems however difficult to further develop this approach. First, the assumption of identical risk-aversion is necessary for the result to hold: in a model where risk-aversion is the agent's private information, Jullien-Salanié-Salanié(2001) shows that a monopoly may optimally propose two contracts which involve a violation of the positive correlation property. Second, the binomial framework is quite particular; the above result cannot be extended to a case with multiple levels of loss.

5 Conclusion

A first lesson stemming from this note is that in an asymmetric information context, a positive correlation between coverage and risk properly restated seems to be a natural and robust consequence of the competitive assumption. In that sense, our paper provides (somewhat *a posteriori*) a theoretical foundation for many existing empirical papers, although it points to the fact that the comparison of risk is not unambiguous and that a proper measure of risk must be used. Proposition 3 is characteristic of a competitive setting. Note nevertheless that one can weaken the zero profit assumption: the proof of Proposition 3 also goes through if we only assume that contracts with a greater coverage make (weakly) lower profits. This is for instance the case in equilibrium in the Miyazaki model of cross-subsidies; thus Proposition 3 also holds in that model. However, Proposition 3 must be restated with proportional loading or taxation, experience rating, or administrative costs of processing a claim.

Under imperfect competition, the zero profit assumption typically does not hold, and the correlation need not be positive. Indeed, the insurance companies extract rent from the insureds, and optimal rent extraction may be such that more profit is extracted on contracts entailing more coverage.

The second lesson is that this property is also natural when risk aversion is public (at least with a single claim) , which encompasses many frameworks Rothschild-Stiglitz (1976) or Chassagnon-Chiapporri (1996). Notice however that public risk aversion is not a natural assumption in the context of insurance, as it eliminates any unobserved heterogeneity on a key determinant of the demand for insurance. One may hardly argue that risk aversion doesn't affect the choice of an insurance policy and the precautionary attitude. Moreover it is an intrinsic property of preferences that cannot be observed by insurers.

Robust departure from the positive correlation property should thus be ground into market power and adverse selection on risk aversion. An example is provided, in a monopoly framework, by Jullien-Salanié-Salanié (2001).

An alternative is to turn the asymmetric information model on its head, by assuming that the insurer actually knows more than the insured. This is done by Villeneuve (2000) within an otherwise standard hidden information model; he indeed finds that the correlation may be reversed, at least in a principal-agent framework. The competitive case however is more tricky, since competition tends in general (but not always) to result in full revelation.

Tests of the positive correlation between risk and coverage on insurance contracts have provided mixed results. Most papers on automobile insurance (see, e.g., Chiappori-Salanié (2000)) cannot reject the no-correlation null: there in fact appears to be no correlation between the coverage of a contract and the ex post riskiness of its subscribers. Puelz-Snow (1994) was an early exception; but Dionne-Gourieroux-Vanasse (2001) attributes their result to a spurious effect of a linear specification. Cawley and Philipson(1999) find no evidence of a positive correlation in their study of life insurance contracts. On the other hand, the market for annuities seems to be plagued by adverse selection problems, as documented by Brugiavini (1993) and more recently Finkelstein-Poterba (2000); Bach (1998) reaches similar conclusions in her study of mortgage-related unemployment insurance contracts. Thus it may be of interest to test predictions that rely on fewer assumptions. Proposition 1 provides one such prediction, as it only relies on a revealed preference argument and does not impose any particular market structure. In fact, it even holds in the Villeneuve model of an informed insurer, provided the insurer does not know everything about the agent and the conditioning variables X include all of the insurer's information. By the same token, a rejection of Proposition 1 would represent a rather strong challenge to the theory.

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Appendix :

Proof of Proposition 1*:* For any claim L, let $W_i(L) = R_i(L) - L - P_i$ be the resulting wealth under contract C_i. Fix the distribution of claims at F_1^θ and define the demeaned wealths

$$X_i(L) = W_i(L) - \int_0^{+\infty} W_i(L) dF_1^\theta(L)$$

By assumption, $X_i(L)$ is non-increasing. Since C_2 covers more than C_1, $(X_1(L) - X_2(L))$ also is non-increasing. It follows that for any X, the difference

$$\Delta(X) = \Pr(X_1(L) \leq X \mid F_1^\theta) - \Pr(X_2(L) \leq X \mid F_1^\theta)$$

is a function of X that can only change sign once, from positive to negative. Now consider the function

$$D(X_0) = \int_{-\infty}^{X_0} \Delta(X) dX$$

Clearly, D can only be increasing then decreasing. Moreover, $D(-\infty) = 0$, and by integrating by parts it is easily seen that

$$D(+\infty) = \int_0^{+\infty} X_2(L) dF_1^\theta(L) - \int_0^{+\infty} X_1(L) dF_1^\theta(L) = 0$$

Thus D is positive everywhere, which by definition implies that under F_1^θ, $X_1(L)$ is a single mean-preserving spread of $X_2(L)$.

Now agent θ prefers C_1 under F_1^θ to C_2 under any F, and in particular under F_1^θ. By assumption 2, the agent is averse to mean-preserving spreads; the fact that he chooses C_1 thus implies that the expected wealth under (C_1, F_1^θ) is larger than that under (C_2, F_1^θ), i.e.

$$\int_0^{+\infty} W_1(L) dF_1^\theta(L) \geq \int_0^{+\infty} W_2(L) dF_1^\theta(L),$$

which yields the result. ■

Proof of Proposition 5 :

Assume that some type θ buys contract C_i, and chooses a probability F_1^θ under C_1. By a simple revealed preference argument, we must have:

$$\int_0^{+\infty} v(-L + R_1(L) - P_1) dF_1^\theta(L) \geq \int_0^{+\infty} v(-L + R_2(L) - P_2) dF_1^\theta(L)$$

Aggregating over the types buying C_1, we find that

$$\int_0^{+\infty} v(-L + R_1(L) - P_1) dF_1(L) \geq \int_0^{+\infty} v(-L + R_2(L) - P_2) dF_1(L)$$

With a similar argument applied on C_2 :

$$\int_0^{+\infty} v(-L + R_2(L) - P_2) dF_2(L) \geq \int_0^{+\infty} v(-L + R_1(L) - P_1) dF_2(L)$$

Taking the difference between the two inequalities yields:

$$\int_0^{+\infty} \phi(L, C_1, C_2) dF_2(L) \geq \int_0^{+\infty} \phi(L, C_1, C_2) dF_1(L).$$

$$\begin{aligned}
\phi' &= \left(v(-L + R_2(L) - P_2) - v(-L + R_1(L) - P_1)\right)\left(R_2'(L) - R_1'(L)\right) \\
\phi'' &= \left(v(-L + R_2(L) - P_2) - v(-L + R_1(L) - P_1)\right)\left(R_2'(L) - R_1'(L)\right)
\end{aligned}$$

Consider two contracts C_1 and C_2, with $I_1 < I_2$. Assume that for any $p_2 < p_1$,

$$V(I_2, P_2, p_2) \geq V(I_1, P_1, p_2) \Rightarrow V(I_2, P_2, p_1) > V(I_1, P_1, p_1).$$

In words, increasing the risk of an accident must favour the contract with higher coverage. This plausible assumption holds as soon as the index of risk-aversion of v does not decrease too rapidly with p. In particular, it holds under assumption **??**.

Now assume that some type θ buys contract C_1, and chooses a probability p_1 under C_1. Then it must be that θ prefers C_1 to C_2 when p_1 is given:

$$p_1 u^\theta(-L+I_1-P_1, p_1)+(1-p_1)u^\theta(-P_1, p_1) \geq p_1 u^\theta(-L+I_2-P_2, p_1)+(1-p_1)u^\theta(-P_2, p_1)$$

which simplifies into

$$V(I_1, P_1, p_1) \geq V(I_2, P_2, p_1).$$

Similarly, if some other type buys C_2, then

$$V(I_2, P_2, p_2) \geq V(I_1, P_1, p_2).$$

Now assuming $p_2 < p_1$ allows to apply the assumption above to the latter inequality, which contradicts the former. Therefore $p_2 \geq p_1$. ■