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Statistical tests of the demand for insurance: an “all or nothing” decision

Anne Corcos[*], *François Pannequin*[†], *Claude Montmarquette*[‡]

Résumé/abstract

We developed and experimentally tested an extended version of Mossin’s traditional theoretical demand for insurance for both risk averters and risk lovers. Both the theoretical model and the experimental data show that the demand for insurance is tantamount to an all or nothing choice. This bimodal distribution of decisions requires an appropriate statistical analysis to confront the data with the model. Thus, this article presents two complementary statistical tests. The first one uses a graphical representation of the experimental results along with a χ^2 test to assess the general goodness of fit of the theoretical model with the data. The second, an econometric model, complements the analysis by assessing the effects of the contractual parameters and risk attitudes on individual demand for insurance. The econometric results show primarily that an increase in the unit price consists in an exit of the insurance market rather than in a contraction of the coverage: as the unit price increases, risk lovers, followed by risk averters, significantly withdraw from the insurance market as they forgo the full insurance contract. However, from the χ^2 test, regardless of their risk attitude, the participants exhibit insufficient demand elasticity to price. Finally, the lack of effect of the fixed cost on risk averters’ demand for partial insurance refutes the inferiority assumption of the demand for insurance.

Mots clés/key words: demand for insurance, experimental study, parametric tests

Codes JEL/JEL codes: C40, C91, D81

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1 Introduction

Society is facing an increasing variety of risks, such as industrial, technological and natural risks, health hazards, climate changes, terrorism, and unemployment. As shown in Outreville's literature review (2013), many research papers outline the relationship between insurance growth and economic growth. Marine and flood insurances, social insurances, industrial investments, and the construction sector are fields where risk management has enhanced economic development. In this context, identifying the determinants of the demand for insurance is crucial.

The standard insurance theory is based on the criterion of expected utility associated with risk aversion. Up to now, empirical works on insurance demand have relied on micro data from insurance companies (including personal data, premiums, deductibles, and repayments) with no consideration for unobservable risk preferences. Indeed, earlier empirical studies on property-casualty insurance (Beenstock et al.,1988, Browne et al., 2000, Esho et al., 2004), along with life insurance (Babbel, 1985, Beck and Webb, 2003) lack information about individuals' risk aversion. These studies sometimes resort to proxies, such as education (Esho et al., 2004) or deductible choices (Carson et al. 2013) to account for risk attitudes. However, some authors have eventually controlled for risk aversion (Kunreuther and Michel-Kerjan, 2015), but their measure has been elicited in the gain domain while insurance belongs to the loss domain.

Furthermore, in the theoretical models, the policyholders are assumed acutely aware of their risk exposure. However, incorrect subjective beliefs could have a significant effect on their revealed demand for insurance. For instance, if the risk exposure is overestimated, a more-than-actuarial insurance pricing would be perceived as very attractive and would drive demand for insurance, instead of discouraging it. If not controlled, the effect of incorrect beliefs weakens the analysis of price sensitivity: following an increase in price, the lack of demand for insurance response could erroneously be interpreted as price-inelasticity instead of a subjective price-attractiveness.

For an insurer, identifying the reason (risk aversion or incorrect beliefs) why individuals purchase an excessive level of coverage when prices are more-than-actuarial is important: the effect of each motivation on demand for insurance is not identical and shapes the insurance contracts. From a public standpoint, the imperfection of individual beliefs might justify public policies to inform people better. Understanding the insurance demand behavior requires, therefore, working on individuals' risk exposure beliefs and their risk preferences. Indeed, laboratory experiments enable us to measure individuals' risk attitude while controlling for their level of risk exposure.

We first extend Mossin's theoretical analysis (1968) to risk loving individuals and study the corner solutions, which mainly provide the determinants of the decision not to buy insurance or to insure fully. Then, we develop an experiment based upon this Mossin-extended-model where several price levels are considered: actuarial and more-than-actuarial prices but also less-than-actuarial prices, as those of public health insurance. We study the impact of a fixed cost as well. To deal with the risk preferences, the Holt-and-Laury-lottery-protocol (2002) has been adapted to classify subjects based on their attitude toward risk (loving or averse) in the domain of losses.

The theoretical analysis highlights a strong "all-or-nothing" insurance demand feature since only risk averse participants confronted with a more-than-actuarial unit price should theoretically choose to cover partially. The theoretical bimodal distribution of the decision is supported by our experimental data and led us to a statistical analysis comprising of two critical dimensions. By controlling for the unit price, fixed cost, and risk attitude, the first one addresses the theoretical validity issue. In experimental economics, in the tradition of Vernon Smith, researchers present graphs, figures, and charts to visualize the causal effects of the experimental results before referring to non-parametric and parametric tests. In this article, we use a simple test that draws on a graphical representation of the experimental results along with a χ^2 test. It assesses the general goodness of fit of the theoretical model with the data and is perfectly adapted to the bimodal nature of our data. The test offers a fast and comprehensive diagnosis of the whole experience without resorting to restrictive and sometimes bold assumptions.

The second dimension of our statistical analysis studies the *individual* insurance demand from a static comparative perspective. The econometric model provides an insight on how the unit price of insurance, fixed cost, and risk attitude intertwine to provide the individual demand for insurance. Our econometric model accounts for the strong bimodality of the experimental data and breaks down the insurance decision for the risk averse participants into the decision not to buy insurance, the decision to subscribe to a full insurance and the choice to cover partially. The risk lovers' choice comes down to no insurance and full insurance.

Both the χ^2 test and the econometric model support most theoretical predictions: as the unit price or the fixed cost rises, participants withdraw from full insurance and leave the market. With no statistically significant coefficient estimates for the partial insurance equation, the econometric model confirms that insurance decisions are polarized between no insurance (the exit effect) and full insurance. However, the χ^2 test shows that both risk averters and risk lovers are less sensitive to price than expected: when the fixed cost is zero, some risk-loving participants keep buying insurance despite an actuarial or more-than-actuarial price. In the same way, when the unit price is more-than-actuarial, risk averters' likelihood to fully cover does not sufficiently decrease as expected.

The rest of the paper is organized as follows. Section 2 presents the theoretical model of insurance demand using a two-part premium structure. It emphasizes the consequences of attitudes toward risk - risk-aversion or risk-loving - and yields predictions to be experimentally tested. Section 3 describes the two-step experiment: eliciting the demand for insurance at an individual level and measuring attitudes toward risk. Section 4 presents the experimental results and, accounting for both risk attitudes and contractual parameters it examines, with appropriate statistical tools, to what extent the observed behaviors fit with the theoretical predictions. Section 5 concludes.

2 The Theory of Insurance Demand

2.1 A model of insurance demand with a two-part premium structure

Relying on an insurance pricing based on two components, a fixed cost, and a unit price, we extend Mossin's (1968) canonical insurance demand model and develop the theoretical predictions for both risk averters and risk lovers.

The decision-maker is endowed with an initial wealth W_0, and she is facing a *q*% risk of losing an amount *x*.

When investing in an insurance premium equal to $P = pI + C$, where *p* represents the unit price of insurance, I the indemnity, and *C* a fixed cost (C≥0), the decision-maker receives a compensation amounting to I if an accident occurs. We assume that over-insurance is prohibited so $0 \leq I \leq x$.

Final wealth is random and equal to W_1 in the no loss state, and to W_2 in the loss state:

$$\begin{cases} W_1 & = & W_0 - pI - C \\ W_2 & = & W_0 - pI - C - x + I \end{cases}$$

Accounting for risk attitudes (Risk Aversion (RA) or Risk Loving (RL)) her preferences are represented either by a concave or a convex utility function U(W). In both cases, she maximizes the following expected utility:

$$\begin{aligned} EU(I) &= (1-q)U(W_1) + q\,U(W_2) \\ &= (1-q)\,U(W_0 - pI - C) + q\,U(W_0 - pI - C - x + I) \end{aligned}$$

The decision maker will buy a positive insurance coverage whenever it exists at least one insurance arrangement improving her well-being. This idea is expressed by the following participation condition (PC), where $EU(0) = (1-q)\,U(W_0) + q\,U(W_0 - x)$ represents the expected utility without any insurance coverage:

$$EU(I) \geq EU(0)$$

$$\Leftrightarrow (1-q)U(W_0 - pI - C) + q\,U(W_0 - pI - C - x + I) \geq EU(0) \qquad (PC)$$

Our theoretical framework characterizes the necessary conditions for choosing a positive insurance coverage and, if appropriate, the optimal level of coverage. The first order conditions (FOC) for a positive insurance coverage, and also conditions for corner solutions (market exit and full insurance), are studied in Appendix 1.[1]

2.2 The Theoretical Predictions

The theoretical predictions for the insurance demand in compliance with the theoretical model (prohibiting over-insurance) and our experimental setting are presented in Table 1.

Two fixed costs levels – (C = 0) and (C > 0) – are crossed with three unit price values: less-than-actuarial (p < q), actuarial (p = q), and more-than-actuarial (p > q).

Table 1: Insurance demand by contract and attitude toward risk

	Less-than-actuarial unit price $p < q$		Actuarial unit price $p = q$		More-than-actuarial unit price $p > q$	
	$C = 0$	$C > 0$	$C = 0$	$C > 0$	$C = 0$	$C > 0$
RA	$I^* = x$	$I^* \in \{0,x\}$	$I^* = x$	$I^* \in \{0,x\}$	$I^* \in [0,x[$	$I^* \in [0,x[$
RN	$I^* = x$	$I^* \in \{0,x\}$	$I^* \in [0,x]$	$I^* = 0$	$I^* = 0$	$I^* = 0$
RL	$I^* \in \{0,x\}$	$I^* \in \{0,x\}$	$I^*=0$	$I^*=0$	$I^*=0$	$I^*=0$

Table 1 unambiguously underlines a key feature: the theoretical demand for insurance is polarized between two optimal values: no insurance (0) or full insurance (x). Some exceptions are for risk-averse participants facing a more-than-actuarial unit price.[2]

3 The Experimental Design

The experiment was conducted in Montreal with 117 participants (mainly students but also workers of various ages, both male, and female).

The demand-for-insurance

Our experiment was designed to analyze the determinants of the demand for insurance. Each subject had to participate in six rounds corresponding to six different tariffs. At the beginning of each round, participants were endowed with 1000 UME and faced a 10% risk of losing their entire wealth, which could be covered by purchasing insurance. Paying a premium P at the

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[1] See Corcos, Pannequin and Montmarquette (2017), for a detailed presentation of the model, as well as a full description of the experimental protocol. Note that complementary to the present study, non-parametric tests are also reported in that related paper.

[2] Since RNs are indifferent between all levels of coverage when the unit price is actuarial and the fixed cost is zero, they can also only partially cover.

beginning of the round ensured the subjects received a compensation I for their loss in case an accident occurred in the round. The premium increased with the desired level of compensation according to the following two-part tariff equation, where C and p stand respectively for the fixed cost and the unit price of insurance:

$$P = pI + C$$

The participants had to choose whether to buy insurance and if so, how much. Figure A1 in Appendix 2 is an example of a fee schedule where the unit price is actuarial and the fixed cost is zero.

At the end of the round, the event (accident versus no accident) was drawn at random. In the case of an accident, if the subjects had chosen not to purchase insurance, their entire wealth was lost. They received compensation otherwise. If no accident occurred, the subjects kept their whole wealth (net of the premium if the insurance was subscribed).

Then, the subjects were asked to play five more rounds involving different tariffs. All six contractual prices were obtained by crossing three unit prices (less-than-actuarial, p1, actuarial, p2, and more-than-actuarial, p3) with two levels of fixed cost (0 and 50) according to the experimental design (Table 2):

Table 2: Experimental Plan

	C=0	C=50
p1 = 0.05	Round 1	Round 2
p2 = 0.1	Round 3	Round 4
p3 = 0.15	Round 5	Round 6

The order of the rounds was randomized to avoid potential unintended order effects. To avoid wealth transfers, subjects started each round with a clean slate: previous subjects' earnings and losses were not cumulative between rounds, making the rounds independent of one another. As part of the subjects' remuneration, one of the rounds was drawn at random and played with the net final UME wealth converted into dollars.

The risk attitude elicitation

Before those six demand-for-insurance rounds, the subjects' risk-attitude was elicited using a Holt-and-Laury-adapted procedure. The proposed lotteries involved losses (rather than gains) to fit the insurance context. For ethical reasons, subjects were provided with 10 dollars beforehand to cover their potential losses. As Etchart and L'Haridon (2011) have shown, this provision does not substantially alter the participants' behavior despite a possible house money effect (Thaler and Johnson, 1990). Also, the various offered alternatives (see Table A.2 in Appendix 2), were designed to mimic the coverage option (option A) versus the risk taking option (option B).

As a standard feature, one decision out of ten was randomly selected and the lottery played. The resulting losses, if so, were then further deducted from the subject's prior 10 dollar endowment.

The incentive procedure

The remuneration was threefold: (1) a $10 endowment to cover (2) the potential losses encountered in the risk-attitude-elicitation step and (3) the potential gains from the insurance-drawn round.

The subjects were fully informed in advance of the various components of their gains. The earnings were only disclosed at the end of the experiment avoiding possible wealth effects. The hourly rate of remuneration was about $15.

4 Results

Risk attitudes

Figure A.1 in Appendix 2 displays the risk attitude distribution measured as the number of times a subject chooses the least risky lottery. As the RAs and RNs are not empirically distinguishable (see the Relative Risk Aversion intervals provided in Table A.2 of Appendix 2), they have been combined. RAs (resp. RLs) are those who have chosen option A—the least risky one—at least five times (resp. at most four times). According to our classification of risk attitude, almost 43% of subjects are RLs. This high proportion of RLs is expected with the Holt and Laury protocol applied in the loss domain.

Overall, except for a few subjects whose risk-attitude coefficient exhibits extreme values, 85% of the participants show coefficient values between 3 and 6.

Demand for insurance

For all contracts, the subjects chose an average coverage of 556 EMU, for a mean premium of 71 EMU. These average values should be interpreted cautiously as both Table 1 and the experimental data in Table 3 point out the bimodality of the demand for insurance: 2 values out of 20 have been picked in 57% of the insurance decisions (full insurance has been selected in 36% of cases and no insurance in 21%).[3]

Therefore, statistical analysis of the experimental data calls for the appropriate tools. Two complementary tests are presented. The first one (Section 4.1) examines whether the data is compliant with the theoretical predictions. The second test (Section 4.2) consists of an econometric model of individual demand for insurance developed for comparative static purposes.

[3] The insurance grid included 20 options, including no insurance and full insurance.

4.1 The matching of the observed demand with the theoretical demand: a χ^2 test

The χ^2 test allows for an efficient goodness-of-fit measure of our experimental data. It compares the theoretical and observed distribution of the demand for insurance. The χ^2 test is performed for each situation exhibited in Table 1, providing a control for both contractual parameters and risk attitudes.[4]

For each contract, and depending on the risk attitude, Table 3 provides the theoretical demand for insurance (columns 1a and 1b), the distribution (as a percentage of the population) of the observed demand for insurance for each level of coverage (columns 2a and 2b), and the test of the goodness of fit between the observed and the theoretically expected distributions of demand (columns 3a and 3b).

In the five cases where the theoretical prediction is a unique value (e.g. I* = x or I* = 0), we compared our data with the theoretical distribution in which 100% of observations take the value I*. In each of the four other cases, where the theoretical prediction takes two values {0;x}, the subjects whose observed demand for insurance is either 0 or x have been grouped so we could perform the same test as above. In the two cases where the theoretical demand takes values in the interval [0;x[, all the values inferior to 1000 have been grouped. Then, we tested for the goodness of fit with a theoretical binary distribution in which the demand for 1000 is nil. In the last case, any empirical distribution over the interval [0;x] is compatible with the predicted global demand for insurance.

From Table 3, we see that in 8 out of the 12 cases, the observed behavior is consistent with the theoretical predictions.[5] When the unit price of insurance is less than or equal to the actuarial price, the insurance demand of RAs is in line with the theoretical predictions. On the RLs side, regardless of the unit price level, when the fixed cost is positive they act in compliance with the theoretical model and exit the insurance market.

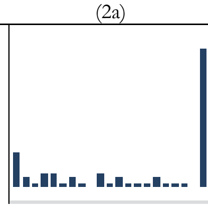
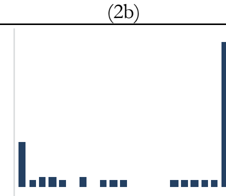
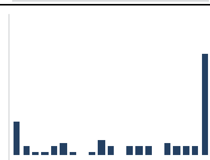
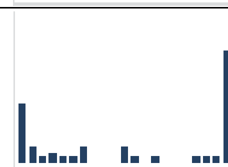
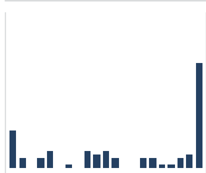
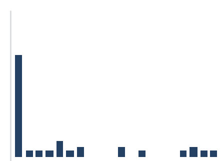
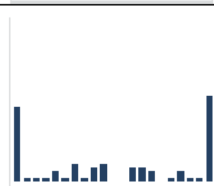
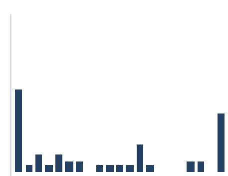
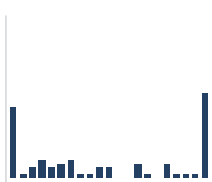
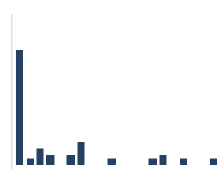
By contrast, in the four cases deviating from the theoretical pattern, both risk-loving and risk-averse subjects exhibit a lack of reaction of the demand for insurance to changes in the unit price: RAs are rather price-inelastic whereas RLs' attractiveness for a nil fixed cost makes them less unit-price sensitive. When the fixed cost is nil (but the unit price equal to or higher than actuarial), the RLs keep buying insurance instead of leaving the market (2 cases out of

[4] RAs and RNs are pooled.

[5] This corresponds to 57% of all the insurance decisions made by all the participants. More precisely, 66.2% (resp. 44.33%) of insurance decisions made by RAs (resp. RLs) are consistent with the theoretical predictions.

4). As for RAs' behavior, when the unit price is more-than-actuarial, the RAs buy full insurance when they are expected not to do so (2 cases out of 4).

Table 3: Test for goodness of fit of the observed distributions to the theoretical distributions of the demand for insurance

Contractual parameters		RA (+neutrality)			RL		
P	C	Theoretical predictions (1a)	Observed Distribution (2a)	χ^2 (p-value) (3a)	Theoretical predictions (1b)	Observed Distribution (2b)	χ^2 (p-value) (3b)
Less-than-actuarial price $p < q$	*C= 0*	I* = x		**AH0** 18.28 (0 .437)	I* ∈ {0,x}		**AH0** 5.12 (0.972)
	C> 0	I*∈{0,x}		**AH0** 13.43 (0 .641)	I* ∈ {0,x}		**AH0** 5.12 (0.883)
Actuarial price $p = q$	*C= 0*	I* ∈[0,x]		**AH0**[a]	I* = 0		**RH0** 30.42** (0 .004)
	C> 0	I*∈{0,x}		**AH0** 16.25 (0.298)	I* = 0		**AH0** 19.22 (0.116)
More-than-actuarial price $p > q$	*C= 0*	I* ∈ [0,x[		**RH0** 5.39* (0 .020)	I* = 0		**RH0** 25.92* (0 .039)
	C> 0	I* ∈ [0,x[		**RH0** 5.39* (0 .020)	I* = 0		**AH0** 16.82 (1.113)

AH0: H0 accepted; RH0: H0 rejected
Thresholds: *5%; ** 1%.
a: trivial case.

We draw the following propositions.

Proposition 1: The RAs' insurance behavior is consistent with that predicted by the theory as long as the unit price is actuarial or less-than-actuarial. Beyond those prices, the RAs' demand for insurance appears to be not price-elastic enough: the RAs' propensity to buy full insurance is too high.

Proposition 2: Regardless of the unit price, when the fixed cost is positive the RLs' behavior is compliant with the theoretical predictions. On the other hand, the zero-fixed-cost attractiveness makes their propensity to participate in the insurance market rather inelastic to an actuarial and more-than-actuarial unit price and, according to theoretical predictions; too many RLs keep buying insurance.

4.2 The econometric model

Providing a comparative static analysis of the data, the econometric model brings further insight at the individual level. According to risk attitudes, the model estimates the effects on the individual demand for insurance of a variation in contractual parameters. For the RLs, to account for the dichotomous features of the insured's choices following the theoretical predictions, the insurance decision has been broken down into the Propensity of No Insurance or Full Insurance (PNIFI). For the RA participants, the decisions have been partitioned into three mutually exclusive elements: whether not to insure (the Probability Not to buy Insurance PNI), whether to get Fully Insured (PFI) and how much Coverage to choose for Partial insurance (PD). The last component is the coverage of insurance of those who decided to buy some, excluding full insurance. For the RAs, the distinction between PNI and PFI is justified by the fact that when prices are more-than-actuarial, individuals can choose to only partially insure. This makes the insurance decision no longer dichotomous.

The following econometric sequence links with our theoretical model.[6]

For the RA participants, the first type of decision is to estimate the determinants of choosing not to insure with a Random effect Probit model (the PNI model). The second kind of decision also refers to a Random effect Probit regression to estimate the determinants of buying full insurance. The third one estimates the demand for partial coverage that is superior to zero

[6] In the spirit of the double-hurdle model of Engle and Moffat (2012), we first considered running a Probit model to account for the observability rule. However, as more than 95% of the individuals who participated in our experiment bought at least one insurance contract, we were unable to converge to a solution with the double hurdle Engle-Moffat Stata procedure. We have, therefore, disregarded the five individuals who never bought insurance.

but inferior to 1000 UME. A robust Random-effects GLS regression will be used to obtain the determinants of partial insurance coverage.
For RL participants, confronted with an unbalanced data set, a linear probability model using a robust Random-effects GLS regression will be used to obtain the determinants of no insurance relative to the decision to fully insure (PNIFI).

The explanatory variables covering all the dimensions of the demand to buy insurance are *DCOST50, DLACT*, and *DMACT*. All are auxiliary variables that describe the pricing of the insurance contract: *DLACT* = 1 if the unit price is less-than-actuarial; *DMACT* = 1 if the unit price is more-than-actuarial, and *DCOST50* = 1 if the fixed cost of the contract is *DCOST50* = 50. The reference variables are, therefore, the actuarial unit price and the zero fixed cost.

Table 4 summarizes the variables and their expected effects for the econometric models derived from the theoretical predictions of Table 1.

For the RAs

According to column (1) of Table 4, relative to an actuarial unit price, a less-than-actuarial price could decrease the probability of the RAs not to buy insurance (DLACT ≤ 0).[7] On the other hand, a more-than-actuarial unit price (DMACT) and a positive fixed cost (DCOST50) could contribute to increasing the probability of the RAs not to buy insurance.

In column (2), we observe that the shift from an actuarial unit price to a less-than-actuarial unit price could increase the likelihood of RAs to fully cover (DLACT ≥0). Also, an expected negative sign is associated with a positive fixed cost (DCOST50 ≤ 0).

The last column of Table 4 related to the RAs deals with the demand for partial insurance (]0;1000[. The RA participants should partially cover only when the unit price is more-than-actuarial.[8] Therefore, we cannot predict the coefficients related to the unit prices of the regression: the partial demand does not exist for a less than or equal to actuarial unit price, and thus the comparison with the situation of a more-than-actuarial unit price is not feasible.

However, as a by-product, under the assumption of Decreasing Absolute Risk Aversion (DARA) the model enables us to test the inferiority hypothesis of insurance. By Mossin (1968), when risk aversion is decreasing in wealth W_0 (with $I > 0$ and $p > q$) an increase in W_0 induces a fall in the demand for

[7] All the inequality signs refer to the sign of the coefficient associated with the variable considered.
[8] And more anecdotally, for the RNs, when the price is actuarial and the fixed cost zero, see footnote 2.

insurance of risk-averters and makes the insurance an inferior good.[9,10] Under the DARA assumption, given a more-than-actuarial two-part tariff, a reduction in the fixed cost component is expected to cause a reduction in the demand for insurance and $\frac{dI}{dC} \geq 0$. The demonstration of this result is identical to that of Mossin provided that the fixed cost is considered as an element subtracted from the initial wealth.

For the RLs

As for the RLs, the insurance unit price plays a leading role in their decision to buy no insurance rather than full insurance. A less-than-actuarial unit price should encourage the RLs to take full insurance instead of no insurance (DLACT < 0). Conversely, regardless of the fixed cost level, when the unit price is actuarial or more-than-actuarial, the RLs are expected not to participate in the market (DMACT = 0).

The fixed cost is relegated to a more distant role, and when the unit price is less-than-actuarial, a positive fixed cost should encourage the RLs not to participate in the market (DCOST50*DLACT > 0) rather than to buy full insurance. However, due to the small number of observations, we only consider DCOST50 > 0.

Table 4: Expected effects of the independent variables

	RA			RL
Explanatory variables	Likelihood not to buy insurance (PNI)	Decision to buy a full insurance coverage (PFI)	Partial Demand for insurance RA participants 0 < PD < 1000	Likelihood not to buy insurance relative to full insurance coverage (PNIFI)
	(1)	(2)	(3)	(4)
DLACT	≤ 0	≥ 0	Nd	< 0
DMACT	≥ 0	< 0	nd	= 0
DCOST50	≥ 0	≤ 0	= 0, > 0 or < 0 *	>0

* Depending on the nature of risk aversion: CARA, DARA or IARA.
nd: not defined

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[9] In this optimization problem, optimal insurance demand *I* is an implicit function of the parameters (W_0, p, C, q). Differentiating the 1st order condition, denoted $H(I) = \frac{\partial EU}{\partial I} = 0$, we get: $\frac{dI}{dC} = -\frac{\partial H}{\partial C} / \frac{\partial H}{\partial I}$. As $\frac{\partial H}{\partial I} = \frac{\partial^2 EU}{\partial I^2} < 0$, the sign of this impact is determined by the sign of $\frac{\partial H}{\partial C} = p(1-q)U''(W_1) - (1-p)qU''(W_2)$, which finally depends on the difference between the 2 coefficients of absolute risk aversion, evaluated respectively for W_1 and W_2: $-A(W_1) + A(W_2)$ where $A(W) = -U''(W)/U'(W)$.

[10] When wealth increases, aversion to any given risk decreases. The marginal benefit of insurance declines with wealth, so does the demand for insurance.

In Table 5, we report the estimates of the insurance demand models.

The RAs

The probability not to buy insurance or to buy full insurance

In column (1) of Table 5, we report the determinants of not buying insurance using a Random effect Probit regression with 1 if individual *i,* facing contractual parameters *s,* does not buy insurance and 0 otherwise. Likewise in column 2, for the demand for full insurance, with 1 if individual *i,* facing contractual parameters *s,* buys full insurance and 0 otherwise.

All the RAs' theoretical predictions are borne out by the econometric estimations. The threefold estimated model underlines a RAs' behavioral key feature: only a more-than-actuarial unit price determines their insurance decision. It deters the RAs from buying full coverage and drives them out from the insurance market. By contrast, neither the fixed cost nor a less-than-actuarial unit price seems to have a significant impact on any of those components of the insurance demand (PNI and PFI).

The demand for partial insurance

With a random effect unbalanced GLS regression, column (3) in Table 5 reports the determinants of buying partial insurance (excluding 0 and 1000 UME and p = 0.15). With the coefficient estimate of *DCOST50* statistically not different from zero, we reject the inferiority of insurance hypothesis. The constant term (at the 1% level of significance) is statistically significant with a value of 488.40.

The RLs

Referring to a linear probability model (with 1 if individual *i,* facing contractual parameters *s,* does not buy insurance and 0 if buying full coverage), and with a random effect unbalanced GLS parameter estimates, we report in column (4) of Table 5 that all the parameters are significant (at least at a two-tail 10% level). As the unit price increases, the RLs leave the market and simultaneously forgo full insurance. The extent (and the significance) of the crowding out effect decreases with the unit price. If the eviction observed when the price shifts from less-than-actuarial to actuarial complies with the theoretical predictions, the decision observed when switching to a more-than-actuarial price may be surprising since all the RLs should theoretically have left the market as soon as the price was actuarial. This last finding, which does not support the theoretical predictions, is consistent with the RLs' inelasticity to unit price reported in the previous section and related to the H0-rejection-cases. The two statistical tests (χ^2 and the econometric model) show their complementarity and allow for a deeper understanding of the RLs' insurance choices. As pointed out in the previous section, the RLs'-attractiveness-to-a-zero-fixed-cost maintains the RLs in a market they should have already left, canceling out the deterrent effect of high unit prices and making the DMACT coefficient significant.

Accordingly, the fixed cost does deter the RLs from participating in the insurance market at the 3.4% level of significance (one tail test).

Table 5: Estimates of the insurance demand models for the RA participants

	RAs			RLs
Explanatory variables	Likelihood not to buy insurance (PNI)	Decision to buy a full insurance coverage (PFI)	Partial Demand for insurance 0 < PD < 1000	Linear probability not to buy insurance (PNIFI)
	(1)	(2)	(3)	(4)
DLACT: 1 if the unit price is less than actuarial (0.05); 0 otherwise	- 0.092 (0.739)	0.326 (0.113)		-0.226*** (0.002)
DMACT: 1 if the unit price is more than actuarial (0.15); 0 otherwise	0.747*** (0.003)	-0.515** (0.017)		0.154* (0.059)
DCOST50: 1 if fixed cost = 50; 0 otherwise	- 0.008 (0.969)	-0.127 (0.457)	-71.257 (0.191)	0.119* (0.076)
Constant	- 1.956*** (0.000)	-0.346 (0.183)	488.40** (0.000)	0.368*** (0.000)
Observations	384	384	63	176
Number of subjects	64	64	38	39
Wald chi2	13.54 (0.004)	15.04 (0.002)	1.71 (0.191)	29.29 (0.000)
Rho	34.12*** (0.000)	118.27*** (0.000)	$R^2 = 0.013$	$R^2=0.122$

p-values in parentheses (two-tail tests): *** p < 0.01, ** p < 0.05, *p<0.1

The findings further suggest that the RLs leave the market first (DLACT coefficient only significant for the RLs) followed by the RAs (DMACT coefficient significant for both RAs and RLs)

Proposition 3: As the unit price increases, participants (RLs first, then RAs) forgo full insurance and leave the insurance market. This underlines, if necessary, the all-of-nothing feature of the insurance decisions.

Proposition 4:
The only significant effect of a positive fixed cost is to crowd the RLs out of the insurance market.

5 Discussion and Conclusion

This paper examined the demand for insurance of risk-loving and risk-averse individuals. We took into account the bimodal nature of the experimental data using a test for goodness-of-fit. In our econometric model, we also disentangled the individual decision not to buy insurance from that of buying full insurance. Each analysis casts light on complementary aspects of the demand for insurance. The χ^2 test provides a static analysis and a global fit between the theory and the data, controlling for contractual parameters and risk attitudes. The econometric model provides a comparative static analysis of the individual demand for insurance. Both tests confirm the strong attraction to the corner solutions predicted by the theory: full insurance coverage or no insurance.

The econometric model specifically examines the role played by the key contractual factors on the individual propensities to buy no insurance and to fully insure. A rise in the unit price of insurance has a detrimental effect on both risk lovers' and risk averters' demand for insurance: as the unit price increases, risk-loving participants are the first to forgo full coverage and to exit the insurance market, followed by risk averters. However, the fixed cost encourages only risk lovers to leave the insurance market.
Our econometric model also examines the risk averters' partial demand for insurance. As a by-product, the use of a two-part premium structure enables to test a key prediction of insurance theory: the inferiority of insurance demand. According to this prediction, as the fixed cost rises (equivalent to a wealth reduction), the demand for insurance of a risk averter paying a more-than-actuarial price should increase. Our experiment does not bring any empirical support to this prediction. Favoring the CARA assumption, no significant change in the partial demand is induced by a rise in the fixed cost.

The χ^2 tests shows that while participants behave mainly in compliance with the theoretical predictions, the four cases where the theory is violated (risk lovers' attractiveness to nil fixed cost and risk averters' insufficient elasticity to unit price) points to a unit price elasticity that falls short of the theory. Too many subjects chose full instead of partial insurance. Also, too many of them keep participating in a market they should have left at the more-than actuarial unit price.

This experimental observation corroborates the empirical observations of Sydnor (2010) who finds that there is an excessive preference for contracts with low deductibles. Indeed, empirical studies show that policyholders would be willing to pay higher premiums for enhanced guarantee (contracts with low deductibles). As Sydnor points out, in an expected utility framework, to be rational, those choices would require exaggerated levels of risk aversion. There are several reasons for such behavior, including the fact that they only imperfectly know their objective risk exposure: if the policyholder's risk exposure expectation is erroneously high then, even more-than-actuarial unit prices could be perceived as attractive. Our experimental approach allows for controlling of the objective risk exposure's knowledge. Our data shows that despite perfectly informed subjects, low deductible contracts keep being overly appealing.

In an expected utility framework, the probability distortion could provide another possible explanation for excessive demands for insurance. According to the predictions of the prospect theory or the RDU model (Tversky and Kanhneman (1992), Wakker (2010), Quiggin (1993)), the work of Kahneman and Tversky (1979) shows that individuals tend to overestimate small probabilities and to underestimate high probabilities. Several recent articles, either theoretical (Eckles and Wise (2013)) or empirical (Barseghyan *et al.* (2013)), have focused on probability distortion in insurance choices and could explain why insurance contracts involving full coverage or low deductibles act as a magnet for policyholders.

Hence, empirical findings with microdata exhibit an overweight of low probabilities and an overstatement of risk exposure perception in the expected utility framework. In our experimental setting, we only controlled for the subjects' knowledge of their objective risk exposure, not for the probability distortion that could occur in their decision-making process. Further lab or field experiments seem necessary to address both distortions issues on the demand for insurance.

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Appendices

Appendix 1

The decision maker, whether risk-loving, risk-neutral, or risk-averse, takes into account the participation condition (PC): $(1-q)U(W_0 - pI - C) + qU(W_0 - pI - C - x + I) \geq EU(0)$, and solves the following problem:

$$\max_I EU = (1-q)U(W_0 - pI - C) + qU(W_0 - pI - C - x + I)$$

A.1.1 For a risk averter (RA), the utility function is strictly concave, and if condition (PC) is satisfied, the following first-order condition (FOC) characterizes the optimal level of coverage for an interior solution:

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

The second-order condition is trivial.[11] Then, the FOC and the condition (PC) give rise to the main features of interior solutions.

When the unit price of insurance is actuarial ($p = q$), the optimal choice for the RA is to buy a complete coverage ($I^* = x$) or no insurance if $C > \hat{C}^*$.

When the unit price of insurance is less than actuarial ($p < q$), an RA prefers to be over-insured (so $I^* = x$ since over-insurance is not allowed), except if C is too high.

When the unit price of insurance is higher than actuarial ($p>q$), an RA individual opts for a partial insurance coverage $(I^* < x)$ or no insurance if C is a deterrent.

To consider the corner solutions (the exit and full insurance conditions), we need to evaluate the FOC at I = 0 and I = x:

$$\left.\frac{\partial EU}{\partial I}\right|_{I=0} = -p(1-q)U'(W_0 - C) + (1-p)qU'(W_0 - x - C) \leq 0 \quad \text{(FOCa)}$$

$$\left.\frac{\partial EU}{\partial I}\right|_{I=x} = (q-p)U'(W_0 - px - C) \geq 0 \qquad \text{(FOCb)}$$

The decision maker (DM) will leave the market under two circumstances:

- If (FOCa) is satisfied (which needs p>q since marginal utility is decreasing and implies condition $(\overline{PC})$: $(1-q)U(W_0 - pI - C) + qU(W_0 - pI - C - x + I) < EU(0); \forall I \in [0; x]$);
- If (FOCa) is not satisfied but $(\overline{PC})$ is;

Condition $(\overline{PC})$ is more likely to occur with high values of p and C since the left-hand side of this inequality is decreasing with p and C. Condition (FOCa) is decreasing with p but has an ambiguous behavior when C varies. If (FOCa) is true, then the left-hand side term of this inequality is decreasing with C if utility is CARA or DARA; if (FOCa) is wrong, the effect of a rise in C would be ambiguous under the same requirements for the utility function, but it would boost the chances to satisfy $(\overline{PC})$.

Thus, *the likelihood of a market exit increases with p (for p>q) and with C.*

[11]For a risk averter, the marginal utility is decreasing and we get: $\frac{\partial^2 EU}{\partial I^2} = p^2(1-q)U''(W_1) + (1-p)^2\, qU''(W_2) < 0$.

The DM will choose a full insurance coverage if conditions (FOCb) and (PC) are simultaneously satisfied. This scenario requires p≤q and C to be relatively low.

A.1.2 For a risk-neutral (RN), the solution is trivial. An RN agent will find it profitable to get insured if the mathematical expectation of I is higher than P, so that qI ≥ pI + C.

For an actuarial unit price (*p* = *q*), a RN is indifferent to the level of coverage ($I^* \in [0,x]$) *if C = 0* and chooses no insurance ($I^* = 0$) if *C > 0*;

For a more-than-actuarial unit price (*p* > *q*), no insurance is purchased ($I^*=0$) at any fixed cost (*C* ≥ *0*);

For a less-than-actuarial unit price (*p* < *q*), the RN agents' demand for insurance is dichotomous: full insurance ($I^* = x$) is optimal when the fixed cost is nil; if *C > 0*, it is optimal to buy a full-insurance coverage ($I^* = x$) or no insurance at all ($I^*= 0$) if the fixed cost is dissuasive.

Again, *the likelihood of a market exit (resp. full insurance) increases (resp. decreases) with p and C. To summarize, for an RN individual, if px + C≥ qx, the market exit is optimal while full insurance is optimal if px + C ≤ qx.*

A.1.4 For a risk-lover (RL), the expected utility is a convex function of the indemnity *I*. Since marginal utility is increasing (*U"(W) > 0*) the second order condition is positive and only corner solutions (no insurance or full coverage) are likely to be observed.

For an actuarial or a more-than-actuarial unit price of insurance (p ≥ q), (FOCa), the FOC evaluated at the no-insurance point (I = 0), is negative;[12] this is also true at the full insurance point (I = x).[13] In other words, due to the convexity of expected utility, the geometrical locus of all insurance coverages (for 0 ≤ I ≤ x) belongs to the decreasing segment of the function EU(I). In this case, the optimal demand for insurance is zero.

For a less-than-actuarial unit price of insurance (p < q), an RL chooses to either self-insure (I* = 0) or buy full insurance (I*= x).[14] In fact, in this case, the minimum of the function EU(I) is on the left of the point of full insurance (since this time, $\left.\frac{\partial EU}{\partial I}\right|_{I=x} > 0$), and we expect full insurance to be preferred to facing the risk (i.e. EU(x) > EU(0)). Again, condition (PC) needs to be true, and the presence of a fixed cost may cause market exit.

An RL is, therefore, facing a binary decision: buying full insurance only if the unit price is sufficiently lower than the actuarial unit price – not buying insurance otherwise.

Once more, the likelihood of a market exit (resp. full insurance) increases (resp. decreases) with p and C. For an RL decision maker, the market exit is optimal as soon as px + C≥ qx, while full insurance requires that px + C is sufficiently below qx (px + C< qx is necessary but not sufficient).

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[12] Since $W_0 > W_0$-x, U'(W_0) > U(W_0-x), since the RL's marginal utility is increasing with wealth, and $\left.\frac{\partial EU}{\partial I}\right|_{I=0} = -p(1-q)U'(W_0) + (1-p)qU'(W_0 - x) < 0$.

[13] $\left.\frac{\partial EU}{\partial I}\right|_{I=x} = (q-p)U'(W_0 - px) \leq 0$

[14] Again, full insurance is preferred since over-insurance is precluded.

Appendix 2

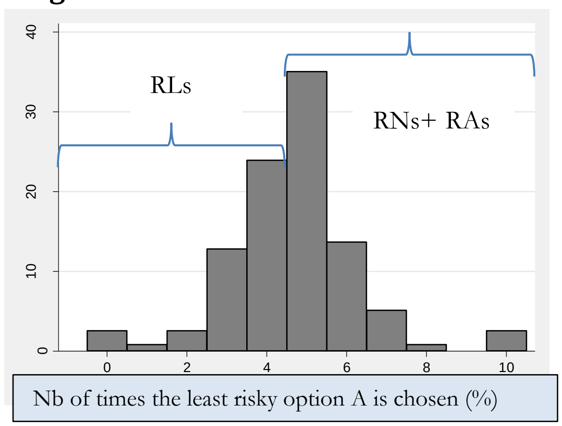
Table A.1: Insurance premium grid

Premium = Total cost of insurance	**Indemnity**	**Wealth at the end of period**	
$p = 0.1$	Compensation in case of accident	If no accident	If accident
C = 0		1000 - premium	1000 - premium - 1000 + indemnity
0	0	1000	0
5	50	995	45
10	100	990	90
15	150	985	135
20	200	980	180
25	250	975	225
30	300	970	270
35	350	965	315
40	400	960	360
45	450	955	405
50	500	950	450
55	550	945	495
60	600	940	540
65	650	935	585
70	700	930	630
75	750	925	675
80	800	920	720
85	850	915	765
90	900	910	810
95	950	905	855
100	1000	900	900

Table A.2: Measurement of risk attitudes

Decision	% likelihood	Loss (in $)	% likelihood	Loss (in $)	% likelihood	Loss (in $)	% likelihood	Loss (in $)	Expected Payoff Difference E(A)-E(B)	RRA intervals[15]
	Option A				Option B					
1	10	-4	90	-6	10	0	90	-10	3.2	]-∞; -0.808]
2	20	-4	80	-6	20	0	80	-10	2.4	[-0.808; -0.62]
3	30	-4	70	-6	30	0	70	-10	1.6	[-0.62; -0.427]
4	40	-4	60	-6	40	0	60	-10	0.8	[-0.427;-0.224]
5	50	-4	50	-6	50	0	50	-10	0	[-0.224; 0]
6	60	-4	40	-6	60	0	40	-10	-0.8	[0; 0.257]
7	70	-4	30	-6	70	0	30	-10	-1.6	[0.257; 0.573]
8	80	-4	20	-6	80	0	20	-10	-2.4	[0.573; 1]
9	90	-4	10	-6	90	0	10	-10	-3.2	[1; 1.712]
10	100	-4	0	-6	100	0	0	-10	-4	[1.712; +∞[

Figure A.1: Risk attitude distribution



[15] Following Chakravarty and Roy (2009), we assume that the subjects' utility functions are CRRA (Constant Relative Risk Aversion) i.e. such that $u(w) = -(-w)^k$ with $w < 0$. By observing when a given subject switches from option A to option B, it is possible to identify into which interval the relative risk attitude falls.

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