TESTING ADVERSE SELECTION AND MORAL HAZARD ON FRENCH CAR INSURANCE DATA

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This paper is a modest contribution to the stream of research devoted to find empirical evidence of asymmetric information. Building upon Chiappori and Salanié's (2000) work, we propose two specific tests, one for adverse selection and one for moral hazard. We implement these tests on French car insurance data, circumventing the lack of dynamic data in our data base by a proxy of claim history. The first test suggests presence of adverse selection whereas the second one seems to contradict presence of pure moral hazard.

Keywords: empirical evidence of moral hazard, adverse selection, car insurance.

JEL Classification: C35, D82.
1. INTRODUCTION

There has been an intensive line of research in the last decades devoted to find empirical evidence of asymmetric information on insurance data. Under adverse selection, the insured has some private information about his type of risk, which the insurer cannot observe before the subscription of an insurance contract. The adverse selection assumption stipulates that the high-risks tend to choose more coverage than the low-risks (Rothschild and Stiglitz (1976), Wilson (1977), Spence (1978)). Under moral hazard, the policyholder can change his preventive behavior after contracting. For example, a policyholder can reduce his prevention effort after subscribing a contract with high coverage (Shavell (1979), Holmstrom (1979), Arnott and Stiglitz (1988)). Both adverse selection and moral hazard have been intensively studied in an insurance context and they may take several forms. Any situation in which the insurer faces an heterogenous population of insured, characterized by a type that is private information to them, adverse selection is at stake; this covers as many different phenomena as individual unobservable risk known by the insured, heterogenous risk aversion, income.... Ex-ante moral hazard, deals with the case where the agent chooses a level of effort after the contract is signed; in insurance, this is relevant to capture the idea that a contract with a high deductible will induce some prevention effort from the policyholder and therefore will decrease his accident probability. On the insurance company side, a wide range of contracting instruments may be used to provide suitable incentives: premia, deductibles as well as experience rating systems like the French "bonus/malus" system.

A typical prediction of, either moral hazard or adverse selection on car insurance is the fact that more coverage implies a higher accident probability. Indeed, under pure adverse selection case, riskier agents choose contracts with high coverage. Under pure moral hazard, it is the fact that agents have a high coverage that induces them to choose a low effort and thus affects positively their accident probability. In both cases, one should observe a positive correlation (conditionally on the variables that are observable by the insurer) between coverage and risk. This in particular led Chiappori and Salanié (2000) to develop a conditional correlation approach between coverage and accidents and they found no evidence of asymmetric information in their data. The robustness of this approach is outlined in Chiappori et al. (2006). For other empirical studies on car insurance data, we refer the reader to Boyer and Dionne (1989), Puelz and Snow (1994), Dionne, Gouriéroux and Vanasse (2001), Cohen (2005), Saito (2006), Vasyechko et al. (2008) and the references therein.
Distinguishing between adverse selection and moral hazard is a difficult task since it requires to identify in which direction is the causality between risk and coverage. To specifically test for moral hazard effects, one should use dynamic data. In fact, on one period-contracting data, the type of asymmetric information cannot be identified with the positive correlation approach whereas, dynamic insurance data can distinguish between moral hazard and adverse selection (Dionne et al. (2004), Abbring et al. (2003a, b), Dionne et al. (2013)).

In the present work, we are interested in specific tests for adverse selection and moral hazard on French car insurance data. We do not really have panel data, but some dynamic dimension is present in our records thanks to the French experience rating system of "bonus/malus" which is based on past claim history. Taking advantage of this "bonus/malus" coefficient in our data base, we can reconstruct a proxy of past claim history, and crossing this factor with current coverage choice gives a specific test for adverse selection. Under adverse selection, a positive correlation is expected which a priori could be not be explained by pure moral hazard (i.e. by past efforts). As far as moral hazard is concerned, the theory predicts that a premium discount, as in the case of a bonus increase, lowers the incentive for prevention effort, resulting eventually in a higher accident probability. On the contrary, agents with a malus tend to increase their prevention effort. This is why we test the negativity of the correlation (again conditional) between the malus and current risk and argue that this test is specific to moral hazard.

The paper is organized as follows. Section 2 presents the data base and explains how to build a relevant proxy of claim history. In section 3, we recall how some implications of theoretical asymmetric information models can be tested on car insurance data. We emphasize the fact that tests based on accident history rather reflect adverse selection whereas crossing experience rating data with accident data is better suited to detect moral hazard. The results of both tests of adverse selection and moral hazard on our French car insurance data base are presented in section 4. Section 5 concludes. The output tables for the parameter estimates of the bivariate probit models upon which our tests are built are gathered in the appendix.

2. PRESENTATION OF THE DATA

Our empirical study is based on a data set provided by a French insurance company. This data set is a cross-section one concerning the year 2004, it is a random sample of the
whole portfolio and contains 44,696 observations. Each observation corresponds to a couple (car, policyholder).

The data set contains the following individual information for each policyholder:

1. the demographic and driving characteristics of the policyholder,
2. the characteristics of policyholder's car,
3. the coverage choice,
4. the characteristics of the accidents recorded by the insurer during the current year.

To be more precise, we describe the four previous items.

- **The demographic and driving characteristics of the policyholder**

  *The age and the gender.*

  *The driver status.* It is a binary variable that indicates if the insured is the principal or secondary driver. It is important to notice that infractions committed by secondary drivers affect the principal driver's premium.

  *The residence area of the policyholder.* It is a binary variable that indicates rural or urban areas.

  *The age of driving license.* This variable gives the seniority of the driving license.

  *The Bonus-Malus (BM) coefficient.* This system is regulated and spelled out by law since 1984 on all French insurance companies. It is a multiplicative coefficient: new policyholders begin with a rate equal to one. The coefficient decreases every year by 5% if no responsible accident occurs during the current year. However, in the case of an accident, the BM coefficient increases by 25%. It cannot be lower than 0.50 and higher than 3.50 (see Grun-Réhomme (2000) for more details). Thirteen accident-free years are required to obtain the maximal bonus. An important characteristic of the BM rate is its transferability from one insurer to another. According to many insurers, the BM system is a source of reliable information on individual risk.

- **The characteristics of the insured vehicle**

  *The effective power of the vehicle.* The insurer asks for the Deutsche Industrie Normen (DIN) horsepower of the car. (It is measured at the output shaft of an engine fully equipped with normal accessories).

  *The age of the car.* Most insurance companies usually propose decreasing prices with the age of the car. As the car gets older, an insured pays less insurance premium, due to the decreasing value of the car on the second-hand market.
The coverage choice

The insurance company offers a menu of contracts after obtaining all the observable information from the policyholders. This menu contains a third-party insurance contract and three comprehensive insurance contracts (full coverage insurance) differentiated by the value of the deductibles which are fixed by the company. When a policyholder declares an accident at fault, the indemnity is equal to the total loss minus the deductible. If the latter exceeds the amount of loss, no reimbursement is due.

Potential policyholders have to choose one of the following contracts:

The third-party (TP) insurance contract. It is compulsory liability insurance. It covers property damages (following climatic events, attacks, natural disasters) and bodily injuries of a third party when the driver is at fault (totally or in part). It includes also a guarantee covering travel assistance and domestic assistance in case of physical injury and a guarantee of legal advice.

The full coverage Formula 1. It is a comprehensive insurance including third-party insurance enlarged by coverage of all damages to the insured car when the policyholder is at fault, with a high deductible.

The full coverage Formula 2. It is a comprehensive insurance with a medium deductible, lower than the Formula 1’s one.

The full coverage Formula 3. It is a comprehensive insurance with the lowest deductible.

Remark that the premium and the deductibles are unknown variables. Indeed, the insurer considers them as being highly strategic variables. For that reason, the insurer refuses to communicate them.

The characteristics of the accidents recorded by the insurer during the current year

The number of accidents: It corresponds to the claims declared and recorded during the year 2004 by the policyholder to the insurance company. It may therefore differ from the total number of accidents during this period. In certain cases, the insured can decide not to claim all accidents to the company.
2.1 A proxy of claim history

Usually, insurers tend to view as good drivers only those with a maximal bonus of 0.50. However, some policyholders who have not reached the maximum bonus still should be regarded as good drivers. Recalling that thirteen years without accident at fault are required to obtain the maximal bonus, a 10-years-driving-experienced policyholder who has never declared any responsible accident to his insurer cannot reach a bonus of 0.50, but he cannot be excluded from the good-drivers category. This shows that in addition to the BM rate, one should take into account the driving experience and thus allow for a larger population of good drivers.

We therefore propose to build an indicator of past claims which crosses the BM coefficient and the driving license seniority. We know that the BM rate is based on the past recorded responsible accidents. However, taking into account only this variable does not provide a good evaluation of the past claims. In fact, a 5-years-licensed and insured driver, who has never claimed any accident at fault, has a BM rate of 0.775 whereas, a policyholder, who had a BM of 0.50 and has just recorded a responsible accident, has a BM rate of 0.625. If we compare only the BM rate of these two drivers without taking into account the seniority of driving license, one can say that the second driver is better than the first one, because his BM rate is smaller. This is not true. Of course, crossing the BM rate and the seniority of the driving license allows us to have, not the frequency of the past accidents, but a good idea about their occurrence, i.e. whether the policyholder has recorded at least one responsible accident in the past.

Let $p_{S_i}$ denote a binary variable describing the past claims history, and more specifically, the occurrence of past accidents. If we denote $n_i$ the age of the driving license held by a policyholder $i$ and $BM_i$ his bonus-malus coefficient, let $p_{S_i} = 0$, if:

- $n_i \geq 13$ and $BM_i = 0.5$ (maximal bonus as fixed by the law),
- $n_i < 13$ and $BM_i = (0.95)^n_i$ (up to a rounding after the second decimal),

and $p_{S_i} = 1$, otherwise. Since new drivers start with a BM coefficient of 1 and get a reward of 5% reduction per year without responsible accident, $BM_i \geq (0.95)^n_i$ and an equality means that the insured had no responsible accident in the past. Let us point out that this indicator is a proxy of the past claims history. Still, a caution is needed because $p_{S_i}$ may overestimate or underestimate the risk type of the insured. For example, a driver who never declared any responsible accident and has not been insured during several years (and thus, his BM coefficient was not changed because of this period of interruption), is
considered as a bad driver according to our approach whereas, this driver is actually a good one. This example shows that we can have some overestimations of number of bad drivers. Our approach may also be biased and underestimate the past accident history, because some drivers may not declare some responsible accident (when the damage is below the deductible for instance) i.e. there might be some misdeclaration phenomena (or ex-post moral hazard).

3. TESTABLE IMPLICATIONS OF ASYMMETRIC INFORMATION

The seminal paper of Chiappori and Salanié (2000) exploits the fact that under asymmetric information\(^1\) (be it adverse selection or moral hazard), conditional on observable variables, there is a positive correlation between coverage level and risk. More precisely:

- under moral hazard, more coverage induces low effort which, in turn, lowers the accident probability,
- under adverse selection, riskier agents choose contracts with higher coverage (lower deductibles).

In both cases, one should therefore have a positive (conditional on observable variables) correlation between coverage level and risk, observed on a given contracting period. Chiappori and Salanié test of asymmetric information is precisely based on this correlation between contract choice and accident occurrence on a given period (with contract choice at the beginning of the period and accident occurrence during the period covered by the contract). As emphasized by Chiappori and Salanié, the difference between adverse selection and moral hazard lies in the causality between coverage and accidents. In the case of moral hazard, more coverage implies a higher probability of accident whereas, in the case of adverse selection, it is a higher intrinsic risk which implies the choice of a higher coverage by the policyholder. It is very hard to identify the sense of this causality on static data and therefore to distinguish between moral hazard and adverse selection. Only panel data and a dynamic perspective (as for instance in Abbring, Chiappori, Heckman and Pinquet, (2003a), (2003b)) can be used to single out the evidence of a moral hazard effect. We do not really have such panel data in our data base, but thanks to bonus/malus information, we have some records on past accident history and we shall see that one can

\(^1\) Here we only consider the case of individual risk, there may be other forms of asymmetric information: heterogeneity in income, risk aversion, ex-post moral hazard (misreporting)....
take great advantage of this information in testing adverse selection effects or moral hazard
effects in a specific manner.

3.1 **Adverse selection and correlation between claim history and coverage**

In presence of pure adverse selection on risk, i.e. in the case policyholders have an
intrinsic risk that is their private information, we claim that a variant of the Chiappori-
Salanié test of positive (conditional) correlation between *current* contract coverage level
and *past* accident history (the recording of which is accessible thanks to bonus/malus
information) cannot be explained by pure moral hazard and therefore rather singles out the
effect of adverse selection. Indeed under adverse selection, past accident history depends on
intrinsic risk and this private information influences the current contract choice in the
direction of more coverage. On the contrary, under pure moral hazard, residual
unobservable heterogeneity of past accident history only depends on past efforts which a
priori have no effect on the choice of the current contract\(^1\). The variant of the Chiappori-
Salanié test where we use past accident history instead of the current accident records thus
should be able to detect adverse selection.

3.2 **Moral hazard and effect of experience rating on accident probability**

As also underlined by Chiappori and Salanié, the French bonus/malus system and
records concerning the French experience rating system can be useful to specifically test
moral hazard. Indeed, consider the standard moral hazard model where the insured chooses
an effort level \(e\) which induces the accident probability \(p(e)\) (with \(p\) decreasing and
convex in \(e\)) and a separable cost \(c(e)\), facing the contract with premium \(P\) and
deductible \(D\), an insured with initial wealth \(W\), chooses his effort by maximizing his
expected utility i.e. by solving

\[
\max_e \{(1 - p(e))U(W - P - D) + p(e)U(W - P) - c(e)\}
\]

where \(U\) is the insured's utility (concave increasing) function. It is convenient to invert the
relation \(p = p(e)\) and to make the change of variable \(e = e(p)\) (convex decreasing) and
thus to rewrite the previous program as

\(^1\) In fact, this is not totally true, because of the bonus/malus system, indeed, past efforts have an influence
on the current bonus of the policyholder which may affect his contract choice, to avoid this effect we have
introduced the bonus/malus as an explanatory variable on contract choice. Conditional on the bonus/malus and the
other observables, past efforts therefore should have no effect on contract choice.
max\{(1 - p)U(W - P - D) + pU(W - P) + \Phi(p)\}

where \( \Phi(p) := -c(e(p)) \) which is a concave increasing function. Assuming an interior optimum, the insured's optimal probability is given by the condition

\[ \Phi'(p) = \delta U = U(W - P) - U(W - P - D) \]

which shows that the accident probability (respectively the effort) is decreasing (respectively increasing) with respect to \( \delta U = U(W - P) - U(W - P - D) \). In particular, since \( \delta U \) is increasing in the deductible \( D \) and in the premium \( P \) (by concavity of \( U \)), the accident probability decreases with \( D \) and \( P \). Of course, this is nothing else than the classical prediction that under moral hazard, more coverage implies more accidents.

The French experience rating system of bonus/malus consists in changing the contract \((P, D)\) into \((\lambda P, D)\) where \(\lambda > 1\) (malus) in case of past accidents caused by the insured and \(\lambda < 1\) (bonus) in case of no past accident caused by the insured\(^1\). Since \( U \) is concave, one immediately sees that

\[ U(W - \lambda P) - U(W - \lambda P - D) > U(W - P) - U(W - P - D) \]

when \(\lambda > 1\) and

\[ U(W - \lambda P) - U(W - \lambda P - D) < U(W - P) - U(W - P - D) \]

when \(\lambda < 1\).

In other words, applying a malus strengthens the incentives and it will result in an higher effort, or equivalently a lower accident probability. Under moral hazard, there is therefore a negative (conditional on observable variables) correlation between the malus coefficient\(^2\) and the current accident occurrence. We will test this implication of moral hazard on our data. Finally, note that pure adverse selection with individual risk heterogeneity that is private information of the insured cannot explain such a correlation, indeed in such a setting, the malus coefficient should be explained by the agent's risk which rather has a positive effect on accident occurrence. The test of negativity of the conditional correlation between malus (at the beginning of the period) and accident (during the period) is well-suited to take into account the ex-post feature of moral hazard.

\(^1\) In fact the bonus/malus coefficient is cumulated in a multiplicative way with respect to time: one typically starts, when subscribing the first contract with \(\lambda_0 = 1\) and \(\lambda_t = \lambda_{t-1}\mu_t\), where \(\mu_t\) is a reward coefficient depending on the number of accidents caused by the insured between \(t-1\) and \(t\). The minimal value of \(\lambda\) (or maximal bonus) is actually fixed by law to be 0.5 in the French system, and similarly the maximal malus coefficient allowed by the law is 3.5.

\(^2\) Or more precisely the increase of the malus coefficient in the previous period.
4. RESULTS

4.1 The adverse selection test

As explained in paragraph 3.1, we shall test the presence on adverse selection in our data set by testing whether the correlation between claim history and coverage, conditional on observable variables is positive. More, precisely, consider the variables $Y = 1$ in case of past accident caused by the insured and 0 otherwise; $Z = 1$ in case of DV contract (i.e. a contract with full coverage of either formula 1, 2 or 3 as presented in section 2) and 0 otherwise. Let $X$ denote the exogenous variables: gender, age, status (principal or secondary driver), power of the car, car age, driving licence seniority. As for the explanatory variables, for the contract choice $Z$ we have also included the bonus/malus coefficient to rule out moral hazard effect.

We use the following bivariate probit model:

$$Y = 1 \iff X \cdot \beta_1 + \epsilon_1 > 0,$$
$$Z = 1 \iff X \cdot \beta_2 + \epsilon_2 > 0$$

where

$$\begin{pmatrix} \epsilon_1 \\ \epsilon_2 \end{pmatrix} \sim N \left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right)$$

We want to test whether $\rho > 0$ as should be the case under adverse selection on individual risk. The details of the estimated coefficients of the model are given in the appendix. We find an estimate coefficient $\rho = 0.085$ with a Student $t$-value of 8.08 so that is very significant. Since the estimate for $\rho$ is significant and positive, this rather suggests the existence of adverse selection in our car insurance data. Of course, we should be cautious about this interpretation because, there are several variables (mileage and income, in the first place) we do not have access to and which certainly are relevant, and it may well be the case that the remaining heterogeneity captured by $\epsilon_1$ and $\epsilon_2$ is more an effect of these variables than adverse selection.

4.2 The moral hazard test

Let us now consider the test based on the considerations of paragraph 3.2. Again, we used a bivariate probit model exactly as (1) - (2) - (3), the only difference is in the endogenous variables, which now are $Y = 1$ in case of an accident during the current period.

\footnote{See paragraph 2.1 for the precise construction of this variable.}
and 0 otherwise; \( Z = 1 \) in case of a malus larger than the average malus in the same class of driving licence seniority and 0 otherwise. The vector \( X \) of exogenous variables is the same as before, namely: gender, age, status (principal or secondary driver), power of the car, car age, driving licence seniority. As seen in paragraph 3.2, under moral hazard, we should have \( \rho < 0 \). The estimation of the model parameters is detailed in the appendix, it gives an estimated value of \( \rho \approx 0.375 \) with a Student \( t \)-value of 22.20, which seems to reject quite strongly the presence of moral hazard. This positive value \( \rho \) is however consistent with adverse selection and therefore rather confirms the conclusions of the adverse selection test of the previous paragraph.

5. CONCLUSION

In this paper, we have proposed two tests on adverse selection and moral hazard and have implemented them on French car insurance data. The first test is a slight variant of the one proposed in the seminal work of Chiappori and Salanié (2000). More precisely, we have used a bivariate probit model in which the endogenous variables are the coverage level and a proxy of claim history, the test suggests an adverse selection effect. Distinguishing between adverse selection and moral hazard is known to be a difficult problem unless one uses dynamic models and data. In our data base, we do not have such data but, we argue that moral hazard effects entail some negative correlation between current claims and a proxy of accident history (that compares individual malus level to the average malus in the same class of driving licence seniority). In our data, we find a positive correlation which indicates either that there is no evidence of moral hazard or that the revelation effect of unobserved heterogeneity outweighs the moral hazard effect (see the discussion in Pinquet (2012)).

Acknowledgements: The authors gratefully acknowledge Risk Foundation support: Chaire Dauphine-ENSAE-Groupama "Les particuliers face au risque" and ANR Risk.

They also wish to thank the hospitality of Kyiv National Economic University where part of the present research was conducted.
The SAS output tables for the model parameter estimates of the two bivariate probit models are as follows.

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### The adverse selection test

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<thead>
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<th>Parameter</th>
<th>Estimate</th>
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<th>t Value</th>
<th>Pr &gt;</th>
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### The moral hazard test

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### Bonus/Value coefficient equation

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### Estimated correlation

| Xno                            | 0.084636 | 0.010470 | 8.08    | <0.001|   |

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### Bonus/Value coefficient equation

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<th>Parameter</th>
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<td>Driver age</td>
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<td>0.001166</td>
<td>1.23</td>
<td>&lt;0.001</td>
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<tr>
<td>Vehicle power</td>
<td>0.003722</td>
<td>0.000436</td>
<td>2.33</td>
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<tr>
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<td>0.9808</td>
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<tr>
<td>Driver status</td>
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<td>0.012132</td>
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<td>Driving license age</td>
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<td>0.008236</td>
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### Estimated correlation

| Xno                            | 0.375565 | 0.016914 | 22.20   | <0.001|   |
REFERENCES


