Replacement Cost Endorsement and Opportunistic Fraud in Automobile Insurance

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Abstract

Traditional insurance contracts do not offer protection against the replacement value of a vehicle. A replacement cost endorsement gives the opportunity to get a new vehicle in the case of a total theft or in the case of total destruction of the car in a road accident. This type of protection was introduced in Canada in the late 1980's. It is also offered in France and many insurers in the United States are going to move in that direction. We show that holders of car insurance policies with a replacement cost endorsement have a higher probability of theft near the end of this additional protection (usually 24 months following the acquisition of a new car). Our tests indicate that this result is a form of ex-post moral hazard or opportunistic insurance fraud.

Keywords: Replacement cost endorsement, automobile insurance, ex-post moral hazard, insurance fraud.

Résumé

Les contrats d'assurance automobile traditionnels n'offrent pas de protection contre la dépréciation d'un véhicule. Cette protection additionnelle permet à un assuré d'obtenir un véhicule neuf équivalent dans l'éventualité d'un vol total ou d'une destruction complète de son véhicule suite à un accident de la route. Ce type de protection est apparu au cours des années quatre-vingts au Canada et existe également en France. Aux États-Unis, les assureurs automobile songent à offrir une protection similaire. Dans cet article, nous montrons que les propriétaires d'automobiles qui profitent d'une protection contre la dépréciation (*valeur à neuf*) ont une probabilité plus grande d'être victimes d'un vol lorsque cette protection additionnelle arrive à échéance (généralement la protection *valeur à neuf* s'applique à un véhicule neuf pour une durée de 24 mois après son achat). Nos résultats économétriques nous permettent d'associer ce résultat à du risque moral ex-post également appelé fraude à l'assurance opportuniste.

Mots clés : valeur à neuf, assurance automobile, risque moral ex-post, fraude à l'assurance.

1. Introduction

Insurance fraud has become an important economic problem. In the Québec automobile insurance market, the cost of fraud was estimated at $100 million in 1994, just under 10% of total claims (Caron and Dionne, 1997). The Insurance Bureau of Canada has estimated that the total annual cost of liability insurance fraud was about $2 billion in Canada (Medza, 1998), while it is estimated to be nearly $70 billion per year in the United States for all type of claims (Foppert, 1994).

The causes of the rapid growth of insurance fraud are numerous: changes in morality, increased poverty, modifications in the behavior of the intermediaries (medical doctors or mechanics for instance), attitude of insurers, etc. (Dionne, Gibbens and St-Michel, 1993).[1] In this paper, we highlight the nature of insurance contracts. In particular, we test whether the presence of a replacement cost endorsement can be a cause of fraudulent claims for automobile theft. This endorsement was introduced in the automobile insurance market to increase the protection of the insureds against depreciation. It is well know that the rate of depreciation of new automobiles is very high.

Traditional insurance markets do not offer protection against the replacement value of an automobile. Rather, they cover current market value, and when a theft occurs, the insurance coverage is largely partial with respect to the market value of a new automobile. A replacement

[1] For discussions on these motivations, see Abraham and Carrol (1998), Bond and Crocker (1997), Boyer (2000), Crocker and Morgan (1998), Crocker and Tennyson (1998), Dionne and Gagné (1997), Fortin and Lanoie (1992, 1998), Picard (1996, 1998) and Weisberg and Derrig (1991).

cost endorsement gives the opportunity to get a new (equivalent) vehicle in the case of theft or in the case of total destruction of the car in a collision, usually if the theft or the collision occurs in the first two years of ownership of a new automobile. In case of total theft, there is no deductible. Ex-ante and without asymmetrical information, this type of contract can be optimal. The only major difference is the expected coverage cost which can easily be reflected in the insurance premium.

Matters are less simple under moral hazard where the individual can modify his self-protection or prevention activities (ex-ante) and can even falsify the occurrence or defraud the insurer (ex-post). Intuitively, a replacement cost endorsement decreases the incentives toward self-protection since it can be interpreted as more than full insurance when the market value of the insured car is lower than the market value of a new car. The presence of a replacement cost endorsement in the insurance contract may also increase the incentives to defraud for the same reason. For example, the insured may have an incentive to set up a fraudulent theft because of the additional protection given by the replacement cost endorsement. This particular type of fraud is known as opportunistic fraud since it occurs when an opportunity occurs and usually not when an insurance contract for a new vehicle is signed. Alternatively, under adverse selection, an individual may choose to include in his coverage a replacement cost endorsement because he knows he will be more at risk.

In this paper, the theoretical model is limited to ex-post moral hazard or opportunistic fraud. However, the empirical model considers self-protection, fraud and adverse selection. We will see that owners who choose a replacement cost endorsement have a higher probability of theft in the last year during which the endorsement is still valid. We interpret this result as ex-post moral hazard or opportunistic fraud. Our tests rule out ex-ante moral hazard because there is no significant effect on partial thefts although the same self-protection activities affect the two claim distributions. We also rule out adverse selection because the statistical effect is obtained for only one year of ownership and not for all years.

The paper is organized as follows. Section 2 presents the theoretical issues while Section 3 introduces the statistical model. Section 4 is devoted to the description of the data and variables. The estimation results are presented in Section 5 and a short conclusion ends the paper in Section 6.

2. Theoretical Model

Consider a risk-averse individual who is making the marginal decision of selling his car and filing a claim for theft to insurer. The car is sold on the black market with value $A^* = qA$, where A is its real market value and q is the proportion recovered on the black market. It is assumed that $q \leq 1$ because of the risks associated with the resale of a car presumably stolen. If the insurance contract bears a valid replacement cost endorsement, the individual will receive $L>A$ from the insurer and if not, he will only receive A. As discussed above, our objective is to analyze the effect of the replacement cost endorsement on this opportunistic decision. Consequently, we suppose that this individual has already signed a full insurance contract for automobile theft (there is no deductible for this type of contract).

Without fraud, the individual's wealth determined by nature is $W+A$ where $W \equiv W_o - P$; W is the level of not contingent wealth: this is the initial wealth W_o minus P the insurance premium.[2] An opportunist individual will defraud if and only if:

$$gU(W+qA+L)+(1-g)U(W+qA-F) \geq U(W+A), \qquad (1)$$

where $U(\cdot)$ is the standard von Neumann- Morgenstern utility function with $U'(\cdot) > 0,\ U''(\cdot) < 0$; g is the success probability of fraud. Fraud is costly, so there is a penalty cost (F) when the activity is discovered with probability ($1-g$) by the insurer (legal procedures, fines, etc.).[3] Also, we assume that there is no insurance coverage when fraud is discovered by the insurer ($L=0$). Hence, the insured will defraud when the expected utility of taking a fraud gamble is greater than the utility of not taking this gamble (on fraud gamble, see also Cummins and Tennyson, 1994).

The important behavioral assumption in (1) is that fraud is not found with probability one, in contrast to what is suggested in standard contracts (Townsend, 1979). The probability $1-g$ is lower than one for at least two reasons: either the insurer does not audit the file (absence of full commitment or random auditing) or it audits, but does not find any evidence of fraud even when there is fraud (see Dionne and Belhadji, 1997 and Caron and Dionne, 1997 for detailed analyses of claim auditing in the Quebec automobile insurance market. It is shown by Caron and Dionne that only 33% of the fraudulent claims are detected when audited).

In order to explicit the equilibrium outcomes between the insured and the insurer, we extend the model of Picard (1996) to our application.[4] Since the empirical analysis is oriented

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[2] With a replacement cost endorsement $P=(1+r)P_o$, where P_o is the base premium and rP_o is the expected cost of the endorsement (usually r is equal to 10 or 15%).

[3] For simplicity, we will suppose that $F = qA$ because, usually, F is an increasing function of A.

[4] The models differ in one important aspect. In our model, the success probability of fraud does not correspond to the probability of non audit. In other words, in our model auditing will not be sufficient to deter fraud.

toward the effects of different parameters of the insurance contract, we will limit the theoretical analysis to the equilibrium of the audit game. For matter of space, we consider only the non-commitment case since we believe this case corresponds to the market studied.

As suggested by Picard (1996), the audit game can be described as a three-stage game. The proportion of opportunists in the market is assumed to be s . Since at equilibrium all insurers offer the same insurance contract, it is also clear that this proportion is the same in the portfolio of each insurer. At the first stage, the nature determines whether the insured is honest or opportunist with probability $1-s$ and s respectively. Then, the honest policy holders always tell the truth while opportunists defraud with probability a . Finally, the insurer may decide to audit with probability d . His success probability of detecting a fraudulent claim when auditing is equal to *m*. Therefore, *g* (the success probability of fraud) is equal to $1-dm$.

From (1), we observe directly that the net benefit of fraud for all *L* is a function of both *g* and *A*. Moreover, there exists a success probability $\tilde{g}$ that makes an opportunist indifferent between fraud and honesty (for $F = qA$):

$$\tilde{g}(A,L)U(W+qA+L)+(1-\tilde{g}(A,L))U(W)=U(W+A). \tag{2}$$

Opportunists choose a to maximize expected utility

$$V = a\left[gU(W+qA+L)+(1-g)U(W)\right]+(1-a)U(W+A), \tag{3}$$

which implies that

$$\begin{aligned} a &= 0 \text{ if } g < \tilde{g}(A,L), \\ a &\in [0,1] \text{ if } g = \tilde{g}(A,L), \\ a &= 1 \text{ if } g > \tilde{g}(A,L). \end{aligned} \tag{4}$$

It is clear that a is an increasing function of *g* and *L* since $\tilde{g}(A,L)$ is decreasing in *L*. It implies that fraud should be more prevalent in contracts bearing a valid replacement cost endorsement since L increases under this endorsement (without the endorsement $L=A$). Also, since $q \leq 1$, we can verify by differentiating (2) that $\tilde{g}$ increases with A. Therefore, it is also clear that as A decreases (as the car is getting older), a increases for a given L. Combined, these two results imply that opportunist individuals are more likely to organize the theft of their vehicle at the end of the contract near the expiration of the replacement cost endorsement or when L-A is high.

The insurer chooses the audit probability d to minimize the expected cost of the claim. Under non-commitment, the audit policy is limited to offering a best response to opportunists' behavior. Using the definition of perfect Bayesian equilibrium, the opportunist strategy will be optimal given the insurer's audit policy and the audit policy will be optimal given the insurer's belief about the probability that a claim can be fraudulent. The insurer's beliefs are obtained from the theft probability g and the fact that opportunists use Bayes' rules in establishing their strategy.

Let us now denote by p the probability for a claim to be fraudulent. Using the above definitions and Baye's rule, we have that

$$p = a s (1-g) / (a s (1-g) + g). \qquad (5)$$

Suppose then that an insured files a claim. The expected cost for the insurer without an audit is equal to L. When auditing, the insurer must pay an audit cost in addition to the expected losses. However, it is assumed that in the case of detected fraud, the insurer gets a reward proportional to F : $t(qA)$, where $0 < t < 1$ is the proportion of the fine recovered by the insurer. Assuming a linear audit cost in m equal to km (where, as a reminder, m is the probability of detecting fraud), the expected cost of the claim with an audit is equal to

$$km + (1 - pm)L - (pmt)qA. \qquad (6)$$

Consequently, under non-commitment, the expected cost of a claim

$$\overline{C} = L + d(km - pm(L + tqA)) \tag{7}$$

is minimized by choosing the equilibrium audit probability d as

$$\begin{aligned} &d = 0 \text{ if } \eth(L + tqA) < k, \\ &d \in [0,1] \text{ if } p(L + tqA) = k, \\ &d = 1 \text{ if } p(L + tqA) > k. \end{aligned} \tag{8}$$

Clearly, d is a decreasing function of k and an increasing function of p, L and A. Consequently, the equilibrium of the audit game can be characterized as follows[5]:

$$\begin{aligned} &d = 0 \text{ and } a = 1 \text{ if } k > \frac{s(1-g)(L+tqA)}{s(1-g)+g}, \\ &d = \frac{1-\tilde{g}(A,L)}{m} \text{ and } a = 1 \text{ if } k = \frac{s(1-g)(L+tqA)}{s(1-g)+g}, \\ &d = \frac{1-\tilde{g}(A,L)}{m} \text{ and } a = \frac{gk}{s(1-g)(L+tqA-k)} \text{ if } k < \frac{s(1-g)(L+tqA)}{s(1-g)+g}. \end{aligned} \tag{9}$$

From the above equilibrium expressions, we can characterize some properties which are tested in the next section. First, we observe that d is increasing in L and A which means that more audit and therefore less fraud should be observed when L and A are high. However, in typical cases, A decreases over time while L is constant. Therefore, for a given contract, d decreases over time. At the same time, a increases because the benefits of fraud for the insured increase as the car is getting older. These results suggest that more fraud should be observed at the end of the period where the replacement cost endorsement applies and that this endorsement should not affect fraud at the beginning of the contract.

In other words, a lower market value A increases the possibility that the cost of audit k will be larger than or equal to $(s(1-g)(L+tqA))/(s(1-g)+g)$ in order to obtain $a = 1$ (an

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[5] See Picard (1996) for a detailed proof of a similar model. Note that d is independent of m in this model where the audit cost is linear in m.

opportunist individual sells is car and claim *L*). When this is not the case, the probability for an opportunist individual to defraud a increases as *A* decreases since $\partial a / \partial A < 0$. This is explained by the fact that a lower market value decreases the net benefit of auditing for the insurer.

3. Statistical Model

A first objective of this study is to verify how the introduction of a replacement cost endorsement affects the distribution of thefts in the automobile insurance market. Another significant objective is to propose an empirical procedure that permit the distinction between the two forms of moral hazard. In other words, we seek to determine whether an increase in the probability of theft may be explained by a decrease in self-protection activities or by an increase in opportunistic fraud. We must also take into account of the adverse selection possibility since the insured ex-ante decision to add a replacement cost endorsement to the insurance policy may be explained by unobservable characteristics that also explain higher risks.

Testing for the presence of information problems is a difficult task (Dionne and St-Michel, 1991; Puelz and Snow, 1994; Butler, Durbin and Helvacian, 1996; Cummins and Tennyson, 1996; Dionne, 1998; Chiappori, 1998). The test must separate the pure information problem effect from all other effects. One way to obtain the desired result is to use a controlled experiment, where agents are distributed among different insurance schemes. But such type of study is very expensive to conduct (see Newhouse, 1987, for an example of this type of study). Another method is to design econometric strategies. Such an approach relies on an econometric model that will distinguish the pure moral hazard effect from other effects that are related to the hidden (unobservable) characteristics of the agents. This difficulty is particularly important when the agents are able to choose their insurance scheme.

Dionne, Gouriéroux and Vanasse (1998) proposed a method that was applied to adverse selection. Here we will extend this method in order to take into account of both forms of moral hazard simultaneously. Furthermore, our approach will allow us to rule out the possibility of misinterpretation of moral hazard under the form of adverse selection.

Let us first consider *y*, an endogeneous binary variable indicating the occurrence of a theft. The decision or contract choice variable *z* (in our case the presence of a replacement cost endorsement) will provide no additional information on the distribution of *y* if the prediction of *y* based on *z* and other initial exogenous variables ***x*** coincides with that based on ***x*** alone. Under this condition, we can write the conditional distribution of *y* as

$$f_y(y \mid \mathbf{x}, z) = f_y(y \mid \mathbf{x}), \tag{10}$$

where $f(\bullet \mid \bullet)$ denotes a conditional probability density function. A more appropriate but equivalent form for our purpose is

$$f_z(z \mid \mathbf{x}, y) = f_z(z \mid \mathbf{x}). \tag{11}$$

In that case, the distribution of *z* is estimated and when condition (11) holds, this distribution is independent of *y* which means that the distribution of theft is independent of the decision variable *z*, here the replacement cost endorsement, since (10) and (11) are equivalent. Our empirical investigation will rely on the indirect characterization as defined by (11). It can be interpreted as the description of how the individual decision affects his future risks (moral hazard) or what would be his decision knowing his future risks (adverse selection).[6]

This type of conditional dependence analysis is usually performed in a parametric framework where the model is a priori constrained by a linear function of ***x*** and *y*, that is

$$f_z(z \mid \mathbf{x}, y) = f_z(z \mid \mathbf{x}'\boldsymbol{a} + by).$$

This practice may induce spurious conclusions, since it is difficult to distinguish between the informational content of a decision variable and an omitted nonlinear effect of the initial

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[6] See Dionne, Gouriéroux and Vanasse (1998) for more details.

exogenous variables. A simple and pragmatic way of taking into account these potential nonlinear effects of $\boldsymbol{x}$ is to consider a more general form

$$f_z(z \mid \boldsymbol{x}, y) = f_z(z \mid \boldsymbol{x}'\boldsymbol{a} + by + cE(y \mid \boldsymbol{x})), \tag{12}$$

where $E(y \mid \boldsymbol{x})$ is an approximated regressor of the expected value of y computed from the initial exogenous information. Assuming normality, $E(y \mid \boldsymbol{x})$ is computed with the parameters obtained from the estimation of y using the *probit* method.

The above framework can be applied to test for different types of information asymmetries. The failure of condition (11) to hold may allow to distinguish between different types of information problems depending on how y is defined. For our purpose, we will define y using 5 different contexts or sub-samples (s):

- $s = 0$ when no theft occurred;
- $s = 1$ if a partial theft occurred at the beginning of the cost endorsement contract;
- $s = 2$ if a partial theft occurred near the end of the cost endorsement contract ;
- $s = 3$ if a total theft occurred at the beginning of the cost endorsement contract;
- $s = 4$ if a total theft occurred near the end of the cost endorsement contract.

Using such a categorization, we may now identify the different types of information problems: adverse selection, ex-ante moral hazard and ex-post moral hazard or opportunistic fraud.

Adverse Selection

Under adverse selection, the hidden characteristics explain the contract choices while under moral hazard (ex-ante or ex-post) the individual actions are explained by the contract choices (Chiappori, 1998). As we discussed in the theoretical models presented in the previous section, the net benefits of fraud or ex-post moral hazard increase over time (i.e. as the car is getting older). If we were in presence of a pure adverse selection effect, the time dimension (that is, the proximity of the expiration of the replacement cost endorsement in the contract, since it is valid for only two years after buying a new car) would not have any importance. In other words, the effect of pure adverse selection would be significant and of approximately the same size whether it is a new contract or an old one. But, if the pattern is not the same over time we would conclude that a pure residual adverse selection effect is absent. Adverse selection would also affect both partial and total theft distributions, since the hidden characteristics of the insured presumably affect the two distributions. However, the effects may not be of the same magnitude. Therefore, with a pure adverse selection effect, condition (11) should not hold in all sub-samples considered (i.e. $s = 1, 2, 3$ and 4).

Ex-ante Moral Hazard

Assuming that the same self-protection activities are involved in the reduction of the probabilities of both types of theft (partial and total), condition (11) should not hold under ex-ante moral hazard for both types of theft. In that case, the presence of a replacement cost endorsement in the insurance contract reduces self-protection activities leading to an increase in the probabilities of partial and total theft. In addition, since the benefits of prevention are decreasing over time, ex-ante moral hazard increases over time. Thus, as for adverse selection, ex-ante moral hazard implies that condition (11) does not hold in all sub-samples considered, but with a stronger effect near the end of the contract (i.e. sub-samples 2 and 4) than at the beginning (i.e. sub-samples 1 and 3).

Ex-post Moral Hazard or Fraud Effect

In the case of opportunistic fraud, the pattern of effects is different. Because the incentives to defraud are very small or even nil in the case of a partial theft, condition (11) should hold in both sub-samples 1 and 2. Also, because the benefits of fraud for total theft are small at the beginning of the contract but increasing over time with a replacement cost endorsement, condition (11) should also hold in the case of a total theft at the beginning of the contract (s = 3). However, near the end the contract, the incentives to defraud reach a maximum only in the case of a total theft when the insurance contract includes a replacement cost endorsement. It follows that with a fraud effect, condition (11) would not be verified in sub-sample 4. Table 1 below presents a brief summary of our observations related to the different asymmetrical information effects.

Table 1 Summary of Asymmetrical Information Effects

Type	Description
Adverse Selection	Significant effects in all cases. Similar effects over time. Effects of approximately the same magnitudes in all cases
Ex-ante Moral Hazard	Significant effects for both types of theft (partial and total). Stronger effects at the end of the contract (sub-samples 2 and 4).
Ex-post Moral Hazard	Significant effect only for total thefts with a stonger effect at the end of the contract (sub-sample 4).

4. Data and Variables

Our data set includes 30,299 automobile insurance policies which were in effect during 1992. The claims associated with these policies all occurred in 1992. Thus, we do not have the claims which occurred in 1993 (particularly in the early months of 1993) for those policies which began in 1992 but ended in 1993. Only policies covering private passenger automobiles are considered for the analysis. Policies covering vehicles such as trucks, buses or motorcycles and automobiles used for commercial activities, such as taxis, are excluded. Also, since a replacement cost endorsement can be valid for 24 months following the delivery of a new vehicle, we limit our sample to policies covering 1990, 1991 and 1992 models. For older models, no replacement cost endorsement can be valid. The policies come from 4 insurance companies in the province of Quebec and they represent, approximately, 8% of automobile insurance policies in Quebec. All data have been provided by the statistical agency of the "Groupement des assureurs automobiles du Québec", an association of automobile insurance companies in Quebec.

The only type of damages considered by these policies are damages to the automobile and its content. Bodily injuries are covered by a separate state owned insurance firm, the "Société d'assurance automobile du Québec". For bodily injuries in Quebec, there is a pure no-fault system that pays 90% of the revenue losses up to a maximum (Boyer and Dionne, 1987; Devlin, 1992). Hospital cares and other medical expenses are covered by the public health care system.

The following variables are used in the analysis:

i) Theft Occurrence Variables (*y*):

PART: a dummy variable with PART=1 if the automobile was the object of a partial theft (for instance the radio or the wheels) in 1992 after the insurance policy took effect; PART=0, otherwise.

TOT: a dummy variable with TOT=1 if the automobile was stolen (total theft) in 1992 after the insurance policy took effect; TOT=0, otherwise.

ii) Contract Choice Variable (*z*):

REPC: a dummy variable with REPC=1 if the insurance policy bears a replacement cost endorsement; REPC=0,otherwise. This endorsement to the insurance policy is granted for 24 months following the delivery of a new vehicle. During that period, no depreciation is considered for a claim settlement associated with a total theft.

iii) Initial Exogenous Variables (***x***):

YR90-YR92: a set of dummy variables with YR(j)=1 if the automobile is a year-model j; YR(j)=0, otherwise. Models 1990 are in the omitted category.

R1-R11: a set of dummy variables with R(j)=1 if the automobile is principally used in region j; R(j)=0, otherwise. The Montreal region is the omitted category. Montreal is the region which is more at risk for automobile thefts.

DURA: the number of months for which the insurance policy was in effect in 1992.

DRC: the principal driver record, measured as the number of years without claim (maximum 6 years).

USE1: a dummy variable with USE1=1 if the principal driver is a man under 25; USE1=0, otherwise.

USE2: a dummy variable with USE2=1 if the principal driver is a woman under 25; USE1=0, otherwise.

F1-F3: a set of dummy variables with F(j)=1 if the policy belongs to company j; F(j)=0 , otherwise.

G1-G6: a set of dummy variables with G(j)=1 if year and automobile model belong to the rating group j; GN(j)=0, otherwise. Rating groups are used to set insurance premiums. They reflect the repair and replacement costs of the automobile (including normal depreciation).

Table 2 presents the frequencies of the discrete variables. The means of the continuous variables used in the analysis are 5.57 for DRC and 4.96 for DURA (most policies are not taking effect on January 1st).

The observed frequencies of partial and total thefts in our sample are similar to the frequencies observed for the entire population of policies. The claim frequencies observed in the population are 1.93% for partial thefts and 2.09% for total thefts. The corresponding claim frequencies in our sample are 1.84% (i.e. 0.77%*(12/4.96)) and 2.32% (i.e. 0.96%*(12/4.96)) respectively for partial and total thefts, when adjusting for the fact that we only observed 4.96 months on average.

Finally, it is worthwhile to note that approximately 31% (9,521 cases) of the policies include a replacement cost endorsement. Two reasons may explain this frequency: some policy holders declined the endorsement at the beginning or the car is more than 24 months old and the replacement cost endorsement is no longer valid (this is more likely in the case of 1990 models). Hence, among the 9,521 policies bearing a replacement cost endorsement in our sample, 7.5% (714 cases) were for 1990 models, 32.3% (3071 cases) for 1991 models and 60.2% (5736 cases) for 1992 models.

(Table 2 here)

Beside TOT, PART and REPC, the above variables represent the information available to the insurance company. REPC is a decision variable which is a function of the characteristics of the insured as well as those of the insurance company. For instance, the price of the endorsement is a fixed proportion of the premium calculated without the endorsement which is specific to each company (10% or 15%). The variables F1, F2 and F3 thus take into account those kinds of firm-specific effects in the REPC models as well as other types of firm effects in the PART and TOT models.

5. Estimation Results

The results of the estimation by the *probit* method are presented in Table 3.[7] The columns labeled REPC 1-4 are different specifications of the replacement cost endorsement model. In REPC-1, beside the exogenous characteristics, only TOT and PART are included in the model. However, these two variable have been divided by DURA (the number of months for which the contract has been valid in 1992) in order to control for the duration of risk exposure. The same transformation has been applied to all REPC specifications considered. The specification REPC-2 is equivalent to REPC-1 except that it takes into account the potential nonlinear effects of the exogenous variables since it includes the expected values of PART (PARTF) and TOT (TOTF). REPC-3 and REPC-4 are the corresponding specifications with year-model specific slopes for both PART and TOT.

Even if both PARTF/DURA and TOTF/DURA are not statistically significant in specification REPC-2, it is better than REPC-1. Using a likelihood ratio test (LR) as a mean of comparison, the assumption that the parameters associated with PARTF/DURA and

[7] We used $E(PART|\boldsymbol{x})$=PARTF=$\boldsymbol{x'b_1}$ and $E(TOT|\boldsymbol{x})$=TOTF=$\boldsymbol{x'b_2}$, where $\boldsymbol{x}$ are the exogenous variables described in the previous section and $\boldsymbol{b_1}$ and $\boldsymbol{b_2}$ are, respectively, the parameter estimates of the partial and total theft equations by the *probit* method. These results are not presented here but are available upon request.

TOTF/DURA are jointly equal to 0 is rejected at the 1% confidence level.[8] In both specifications, the parameter associated with TOT/DURA is positive and statistically significant while the parameter of PART/DURA is not. This result is sufficient to exclude the ex-ante moral hazard explanation. Recall that under ex-ante moral hazard and given that the same preventive activities are involved for both types of theft (partial and total), the occurrences of the two types of theft should bring additional information in the REPC model.

The positive and significant effect of TOT in the REPC model may be the consequence of adverse selection and/or ex-post moral hazard in the form of opportunistic fraud. If car owners specifically choose to buy a replacement cost endorsement because they know that they are more at risk for car theft, the parameter associated with TOT/DURA should be positive and statistically significant even if the car is brand new or it is old enough so that the replacement cost endorsement will soon expire. The inclusion of interaction variables between TOT/DURA, PART/DURA and YR90, YR91 and YR92, will give the pattern of the effects over time. The results associated with such interaction variables are given in column REPC-3 (without nonlinear effects) and REPC-4 (with nonlinear effects). Again here, specification REPC-4 which includes nonlinear effects is dominating. The LR test statistic is 82.76 which means that the parameters associated with the nonlinear effect variables are jointly different from 0. Beside two nonlinear effect variables, only the parameter of the interaction between TOT/DURA and YR90 is positive and statistically significant (at the 5% confidence level). All other parameters associated with the interaction variables involving TOT/DURA are not statistically different from 0 at any reasonable confidence levels. Therefore, the adverse selection explanation can be dropped since with such

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[8] The LR test statistic is 15.02 which is greater that a c^2 with 2 degrees of freedom at the 1% confidence level

effect, all the parameters of the interaction variables between TOT/DURA and the year-model of the car should be positive and statistically significant. Furthermore, the absence of significant parameters associated with the interaction terms between PART/DURA and the year-model is consistent with our previous results in specifications REPC-1 and REPC-2. Therefore, not only that the results from REPC-4 allow us to discard the adverse selection effect but also it still reject the ex-ante moral hazard assumption as all other models did previously.

The only interpretation which remains from the results of specification REPC-4 is that of the ex-post moral hazard or fraud effect. Our results show that the total theft occurrence is a significant factor in the explanation of the presence of a replacement cost endorsement in an automobile insurance contract only when this endorsement is about to expire. The total theft occurrence is not a significant factor neither at the beginning of the contract, nor at a middle stage.

In terms of probabilities, our results are quite interesting. Using the parameter estimates of REPC-4 for the computations, we obtain that the average predicted probability of bearing a valid replacement cost endorsement is 8.51% for 1990 models while the observed probability for the same sub-sample is 7.82%. The corresponding predicted probability for those insureds which did not make a claim for total theft is 8.44% (7.70% observed) while it is 74.79% for insureds who did make a claim for total theft (18.27% observed). This result means that policy holders who made a claim for total theft were 9 times more likely to be protected against depreciation with a replacement cost endorsement than those who did not make a claim for the same reason. For 1991 models, the corresponding estimated relative frequency is not statistically different from 1 (which means that those policy holders who made a claim for total theft had the same probability of having a replacement cost endorsement than those who did not make a claim for total theft) while

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(9.21).

the observed relative frequency is 1.09. Car model 1992 have an estimated relative frequency of also 1 and their observed relative frequency is 1.23. Considering that our results allow us to rule out both ex-ante moral hazard and adverse selection explanations, the only effect which remains is that of ex-post moral hazard associated with opportunistic fraud.

6. Concluding Remarks

In this paper we have proposed a methodology to separate moral hazard from adverse selection. As suggested by Chiappori (1998), one possibility to obtain such separation from claim data is to use a dynamic model. Our data did not allow us to go in that direction. The originality of our methodology, although in the spirit Chiappori (1998), was to use different contracting dates for the replacement cost endorsement but claims over one period. Consequently, we were first able to separate moral hazard from adverse selection since the latter should have the same effect at each period according to the theory. However, our theoretical model showed that the observed moral hazard effect should be more significant at the end of the contract. Finally, we were able to separate between the two forms of moral hazard by using partial and total thefts and by assuming that the same preventive actions affect the two distributions. Our results do not reject the presence of opportunistic fraud in the data which means that the studied endorsement has a direct significant effect on the total number of car thefts in the analyzed market.

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Table 2 Frequencies of the Variables (in %)*
30,299 Observations

Variable	Frequency	Variable	Frequency	Variable	Frequency
PART	0,77	R5	15,6	F1	38,2
TOT	0,96	R6	8,5	F2	18,3
REPC	31,4	R7	12,6	F3	33,0
YR91	28,3	R8	5,5	G1	28,2
YR92	41,5	R9	5,6	G2	38,7
R1	3,4	R10	4,1	G3	19,0
R2	7,0	R11	5,0	G4	6,5
R3	10,4	USE1	2,5	G5	2,7
R4	5,7	USE2	2,8	G6	3,3

* To save on space, the frequencies of DRC and DURA are not reported. However, their respective means are: 5.57 and 4.96.

Table 3 Parameter Estimates
30,299 Observations
(standard error in parentheses)

	REPC			
Variable	1	2	3	4
INTERCEPT	-2.0248*	-1.9866*	-2.0287*	-1.8604*
	(0.0924)	(0.0957)	(0.0925)	(0.0979)
YR91	1.1498*	1.1527*	1.1533*	1.0170*
	(0.0254)	(0.0254)	(0.0256)	(0.0387)
YR92	1.5138*	1.5118*	1.5169*	1.3324*
	(0.0249)	(0.0251)	(0.0251)	(0.0365)
R1	-0.3471*	-0.3542*	-0.3467*	-0.3517*
	(0.0529)	(0.0538)	(0.0529)	(0.0540)
R2	-0.0105	-0.0212	-0.0104	-0.0165
	(0.0370)	(0.0390)	(0.0370)	(0.0391)
R3	0.0111	0.0142	0.0115	0.0202
	(0.0383)	(0.0384)	(0.0383)	(0.0385)
R4	-0.0827	-0.0795	-0.0822	-0.0768
	(0.0434)	(0.0435)	(0.0434)	(0.0436)
R5	-0.1341*	-0.1233*	-0.1338*	-0.1287*
	(0.0294)	(0.0306)	(0.0294)	(0.0306)
R6	-0.0091	-0.0182	-0.0092	-0.0130
	(0.0350)	(0.0367)	(0.0350)	(0.0368)
R7	0.0178	0.0251	0.0179	0.0242
	(0.0310)	(0.0314)	(0.0310)	(0.0314)
R8	-0.0618	-0.0587	-0.0606	-0.0571
	(0.0451)	(0.0452)	(0.0451)	(0.0452)
R9	0.0344	0.0435	0.0346	0.0403
	(0.0403)	(0.0409)	(0.0403)	(0.0409)
R10	0.0382	0.0411	0.0388	0.0418
	(0.0462)	(0.0462)	(0.0462)	(0.0463)
R11	-0.2108*	-0.2007*	-0.2102*	-0.2003*
	(0.0459)	(0.0461)	(0.0459)	(0.0462)
DRC	0.1215*	0.1209*	0.1216*	0.1213*
	(0.0089)	(0.0090)	(0.0089)	(0.0090)
USE1	-0.2147*	-0.2216*	-0.2149*	-0.2210*
	(0.0587)	(0.0589)	(0.0587)	(0.0589)
USE2	0.1366**	0.1344**	0.1348**	0.1345**
	(0.0539)	(0.0540)	(0.0540)	(0.0540)
F1	-0.4116*	-0.3958*	-0.4106*	-0.3953*
	(0.0284)	(0.0287)	(0.0284)	(0.0287)
F2	-1.1751*	-1.1654*	-1.1745*	-1.1709*
	(0.0381)	(0.0393)	(0.0381)	(0.0394)
F3	0.5189*	0.5297*	0.5199*	0.5335*
	(0.0285)	(0.0292)	(0.0285)	(0.0292)
G1	0.0435	0.0278	0.0432	0.0404
	(0.0705)	(0.0726)	(0.0705)	(0.0725)
G2	0.0120	-0.0008	0.0117	0.0051
	(0.0698)	(0.0708)	(0.0698)	(0.0707)
G3	-0.1952	-0.1212	-0.1057	-0.1138
	(0.0712)	(0.0727)	(0.0712)	(0.0725)
G4	-0.1250	-0.1239	-0.1265	-0.1177
	(0.0759)	(0.0760)	(0.0759)	(0.0759)
G5	-0.3142*	-0.2929*	-0.3141*	-0.2908*
	(0.0854)	(0.0879)	(0.0854)	(0.0878)
G6	-0.4733*	-0.4676*	-0.4734*	-0.4658*
	(0.0844)	(0.0845)	(0.0844)	(0.0843)

* (**) denotes statistical significance at the 1% (5%) level.

Table 3 Parameter Estimates (continued)
30,299 Observations
(standard error in parentheses)

Variable	REPC 1	2	3	4
TOT/DURA	1.3603*	1.3087*	--	--
	(0.4589)	(0.4601)		
PART/DURA	0.8486	0.7933	--	--
	(0.5432)	(0.5443)		
(TOT/DURA)*YR90	--	--	3.1319*	2.4658**
			(1.0473)	(1.0722)
(TOT/DURA)*YR91	--	--	1.1169	1.0548
			(0.7816)	(0.7833)
(TOT/DURA)*YR92	--	--	0.9089	0.9274
			(0.6617)	(0.6586)
(PART/DURA)*YR90	--	--	0.2619	-0.1163
			(1.2876)	(1.3710)
(PART/DURA)*YR91	--	--	0.6510	0.5407
			(0.9933)	(0.9972)
(PART/DURA)*YR92	--	--	1.2061	1.2066
			(0.7775)	(0.7778)
TOTF/DURA	--	-0.0932	--	--
		(0.1161)		
PARTF/DURA	--	0.1325	--	--
		(0.1148)		
(TOTF/DURA)*YR90	--	--	--	0.8465*
				(0.2297)
(TOTF/DURA)*YR91	--	--	--	-0.1979
				(0.1581)
(TOTF/DURA)*YR92	--	--	--	-0.2077
				(0.1351)
(PARTF/DURA)*YR90	--	--	--	-0.6159*
				(0.2243)
(PARTF/DURA)*YR91	--	--	--	0.2366
				(0.1556)
(PARTF/DURA)*YR92	--	--	--	0.1957
				(0.1339)
Log(L)	-14215.99	-14208.48	-14214.12	-14172.74

* (**) Denotes statistical significance at the 1% (5%) level.