The Empirical Measure of Information Problems with Emphasis on Insurance Fraud and Dynamic Data[1]

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Abstract

We discuss the difficult question of measuring the effects of asymmetric information problems on resource allocation. Three problems are examined: moral hazard, adverse selection, and asymmetric learning. One theoretical conclusion, drawn by many authors, is that information problems may introduce significant distortions into the economy. However, we verify, in different markets, that efficient mechanisms have been introduced in order to reduce these distortions and even eliminate, at the margin, some residual information problems. This conclusion is stronger for pure adverse selection. One explanation is that adverse selection is related to exogenous characteristics, while asymmetric learning and moral hazard are due to endogenous actions that may change at any point in time. Dynamic data help to identify the three information problems by permitting causality tests.

Keywords: Empirical measure, information problem, moral hazard, adverse selection, learning, insurance fraud, causality tests, dynamic data.

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1. Introduction

The study of information problems in economics began in the early 1960s. The two best known problems, moral hazard and adverse selection, were introduced in the literature in 1963 by Kenneth Arrow in a classic article published in the American Economic Review. In 1970, Akerlof came up with the first analysis of market equilibrium in the presence of adverse selection. Optimal contracts were first characterized endogenously for adverse selection in articles by Pauly (1974), Rothschild and Stiglitz (1976), and Wilson (1977), and for ex ante moral hazard by Holmstorm (1979) and Shavell (1979). Ex post moral hazard was defined early on by Pauly (1968) and was later formalized by Townsend (1979) and Gale and Hellwig (1985).

In the early 1980s, several theoretical developments were advanced to account for different facts observed in several markets. Specifically, dealing with models of two-party contracts, multi-period contractual relations were introduced; the renegotiation of contracts was formalized; the problem of contractual commitments was analyzed; and simultaneous treatment of several information problems became a consideration. Other noteworthy proposals were developed to explain hierarchical relations in firms and in organizations, often involving multi-party participants and contracts.

The economic relationships most often studied were insurance contracts, banking contracts, work and sharecropping contracts, and auctions. Several forms of contracts observed in these markets were catalogued in various theoretical contributions. The best known are partial insurance coverage (co-insurance and deductibles), compensation based on hours worked and performance, executive compensation with stock options, debt with collateral, bonus-malus schemes, temporal deductibles, and venture capital contracts with warrants. There was also rationalization of several corporate organizational practices such as the use of foremen, internal and external controls, auditing, decentralization of certain decisions, and the centralization of more difficult-to-control decisions.

The empirical study of information problems began much later. The main motivation was to distinguish the stylized (qualitative) facts used to construct certain models from real or more quantitative facts. For example, in classroom and theoretical journals, different automobile insurance deductibles can very well be used to justify adverse selection, but there is no evidence that insurers established this partial coverage for that reason. It can also be argued that labor contracts with performance compensation are used to reduce moral hazard in firms, but it has not necessarily been conclusively empirically demonstrated that there is less moral hazard in firms with this form of compensation than in other firms that use fixed compensation, combined with other incentives or control mechanisms to deal with this information problem.

Another strong motivation for empirically verifying the effects of information problems is the search for ways to reduce their negative impact on resource allocation. For example, we know that partial insurance is effective in reducing ex ante moral hazard, as it exposes the insured person to risk. Yet this mechanism is ineffective against ex post moral hazard, because the accident has already occurred. Partial insurance may even have pernicious effects and encourage the padding of costs. The audit of files seems to be the most effective instrument against ex post moral hazard. This shows the importance of identifying the real problem when attempting to correct imperfections and improve resource allocation.

When it comes to empirically measuring information problems and assessing the effectiveness of mechanisms set up to correct them (relationship between the nature of contracts and their performance), numerous complications soon arise. For one, several information problems may be present, simultaneously, in the database studied; the theoretical predictions must then be carefully defined to distinguish the effects of different information problems on the parameters of the models to be estimated. Moreover, firms have a wide range of mechanisms (substitutes or complementary) at their disposal and they may be selected for reasons other than information problems or for information problems other than those investigated in a particular study. In other words, the information problems under consideration are often neither a necessary nor a sufficient condition to justify the existence of certain mechanisms.

Treating several information problems simultaneously is difficult: the literature does not yet offer strong theoretical predictions, even when all available contributions are reviewed. If we simply verify whether a market contains any residual information asymmetry, regardless of its origin, it is easier to demonstrate its absence, because there is no need to distinguish between the different forms of information asymmetry. Otherwise, we have to ascertain which form is still present and document its cause to analyze the instruments that could mitigate or eliminate it.

As a rule, the distinction between moral hazard and adverse selection can be reduced to a problem of causality (Chiappori, 1994, 1999). With moral hazard, the non-observable actions of individuals that affect the way contracts work are consequences of the forms of contracts. For example, a contract may increase the risk of the activity, because it reduces the incentives to act safely.[2] With pure adverse selection, the nature of different risks already exists before the contract is written. The contracts selected appear from the risks present. There is thus a form of reverse causality between the two information problems. When an exogenous change occurs in an insurance contract, we can limit our test to the way it affects existing policy holders and isolate a moral hazard effect. Alternatively, we could make comparisons to see whether the chance of accident differs between new and old policy holders and check for any bias caused by adverse selection. Another way is to use panel data and develop causality tests. However, these tests must consider that other information asymmetries may be present such as the learning of the contract parties over time (Dionne, Michaud, Dahchour, 2011). This learning can be symmetrical or not. Dynamic data are also useful for separating moral hazard from unobserved heterogeneity (Abbring, Chiappori, Pinquet, 1993; Dionne, Pinquet et al., 2005, 2011).

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[2] On the choice of insurance contracts by employees and their anticipated behavioral response to insurance (moral hazard), see the recent study of Einav et al (2012).

Another difficulty in the empirical measurement of information problems is the fact that researchers are not privy to more information than decision makers. Two solutions have been adopted to make up for that difficulty: (1) use of confidential surveys and (2) development of econometric strategies that can isolate the desired effect. The experimental approach is a third avenue that I shall not deal with in detail.

The survey method has the advantage of providing direct access to private information not available to one party to the contract, such as accidents not claimed or risk perception. Such information makes it possible to measure motivations for choosing specific contractual clauses directly, along with agents' behavior. The drawback of this method is that it is very costly. It can also be biased, because it is very difficult to explain the complexity of the problem studied to respondents, and because several alternative explanations might have been overlooked in the questionnaires. Another source of bias is related to the selection of representative samples.

The development of econometric strategies requires knowledge of the theoretical problem under study and of the econometric methods suitable for the project. This is why the most productive research teams are composed of theoreticians and econometricians. The objective is to isolate effects that are not directly observable by both parties to the contract but that are taken into account by certain variables or combination of variables. As discussed by Chiappori (1994) and Gouriéroux (1999), econometric work consists in distinguishing between two sources of information. The first type is composed of variables observable by the two parties to the contract. These variables can be used to make estimates conditional on the characteristics observed. The second type is linked to the information not observable by econometricians (and by at least one contractual party), but that may explain choices of contracts or behaviors. In the case of adverse selection, choices of contracts can be interpreted by econometricians as being a bias of endogenous selection. One way of taking this into account is to estimate agents' decisions simultaneously by introducing hidden connections (or informational asymmetries) between the decisions. One known form is the non-null correlation between the random terms of the different equations (contract choice and accident distributions; Chiappori and Salanié, 2000). Another form entails estimating the parameters of contract choice on contract result (Dionne, Gouriéroux and Vanasse, 2001).

Quality of data is a determining factor in the measurement of desired effects. The data must correspond directly to the contractual relations studied and to the duration of the contractual periods. There must also be access to data broken down contract by contract. The effort involved in formulating raw data for research purposes should not be underestimated. Raw data are used in the day-to-day operations of firms that are not concerned with research problems, and do not always contain direct information on variables needed for the problem studied.

Econometric specifications must correspond to the theoretical models under consideration, if erroneous conclusions are to be avoided. Often, researchers choose (or are forced) to use only part of the information available to decision-makers, and thus bias the effects of certain variables so that they capture the effects of other forgotten or inaccessible variables and obtain false conclusions.

Finally, the agents to different contracts are often risk averse to varying degrees. This characteristic is also difficult to observe and can be a source of asymmetric information. Some authors have recently proposed models taking into account the varying degrees of risk aversion, but very few predictions can isolate the effects of information problems as they relate to varying degrees of risk aversion among agents. These difficulties will be discussed in detail below (see Dionne, Fombaron and Doherty, 2012, for a longer theoretical discussion of adverse selection).

The rest of the paper will look at examples of the empirical verification of the presence or absence of a residual information problem in different markets with an emphasis on insurance markets. These examples highlight various difficulties that are not always well understood by those who tackle the empirical measurement of information problems. The first is a test for the presence of asymmetric information in an insurer's portfolio. One should ask: Is risk classification sufficient to rule out residual asymmetric information or do we need self-selection mechanisms inside risk classes? We also treat the separation issue between moral hazard and adverse selection and how dynamic data can be used to develop tests for the presence of moral hazard when adverse selection is not a significant factor, as in public insurance regimes with compulsory insurance coverage.

The second example deals with labor contracts and compensation methods. Such methods are often observable by econometricians, whereas individual effort is not. Furthermore, individual output can hardly be used to deduce effort, because it depends on several other factors, such as the outcome of a random variable or other non-observable staffing practices.

We next treat ex post moral hazard in insurance markets covering work accidents and medical services. The main difficulty is attributing variations in demand to one of three factors: price variations, moral hazard, and adverse selection. Many studies show that a change in coverage will affect consumption, but few determine whether the cause is moral hazard, for example. The estimated variation may simply be due to the price and wealth effects of insurance. A section on insurance fraud will also be presented. We will see how parameters of standard insurance contracts may affect incentives to defraud and how the development of optimal audit strategies can reduce the presence of fraud.

Finally, we shall discuss price differences in reference to adverse selection in markets for various transactions such as used cars, slaves, and mergers and acquisitions. Can the price differences observed be explained by asymmetric information, and specifically by adverse selection? We will see how adequate data can point to a sequence in the tests to separate adverse selection from asymmetric information.

2. Measurement of Residual Asymmetric Information in Insurance Data[3]

The objective of this section is to present various tests for the presence of residual asymmetric information in insurance markets. From the theoretical literature (Dionne et al, 2012; Picard, 2012; Winter, 2012), we know that the potential presence of asymmetric information between insured and insurers regarding individual risks motivates partial insurance, risk classification, and auditing of claims. It is also well known from the insurance literature that risk classification is due, in part, to asymmetric information between the insurer and the insured (Crocker and Snow, 1985, 1986). Full efficiency in risk classification should separate individual risks and generate different actuarial insurance premiums that reflect these risks (Dionne and Rothschild, 2011; Crocker and Snow, 2012). This means there should not be any residual asymmetric information between the insurer and the insured inside the risk classes. With actuarial premiums, full insurance should be the optimal contract, and there should be no correlation between insurance coverage and individual risk. However, in the real world of insurance contracting, there may be numerous constraints that limit efficiency in risk classification. Incentive contracting thus becomes important, and the empirical question is: how efficiently does this mechanism reduce asymmetric information in insurers' portfolios?

Cohen and Siegelman (2010) present a survey of empirical studies of adverse selection in insurance markets. They argue that the coverage-risk correlation is particular to each market. Accordingly, the presence of a significant coverage-risk correlation has different meanings in different markets, and even in different risk pools in a given market, depending on the type of insured service, the participants' characteristics, institutional factors, and regulation. This means that when testing for the presence of residual asymmetric information, one must also control for these factors. What characteristics and factors explain the absence of coverage-risk correlation in automobile insurance markets? Some studies using the conditional correlation approach on cross-sectional data find evidence of asymmetric information (Dahlby, 1983, 1992; Devlin, 1992; Puelz and Snow, 1994; Richaudeau, 1999; Cohen, 2005; Kim et al, 2009) while others did not (Chiappori

[3] Based on Dionne and Rothschild (2011).

and Salanie, 2000; Dionne et al, 2001; Saito, 2006). One major criticism of the conditional correlation approach with cross-sectional data is that it does not allow separation of adverse selection from moral hazard.

Many theoretical contributions were published in the 1970s to account for stylized facts observed in insurance markets. The first models developed were with one-period or static contracts. Partial insurance, such as deductible and co-insurance contracts, can be justified by asymmetric information (Rothschild and Stiglitz, 1976; Shavell, 1979; Holmstrom, 1979). However, a deductible can be optimal for moral hazard, adverse selection, or proportional administrative costs. As mentioned above, risk classification based on observable characteristics and multi-period relationships between principal and agent are other mechanisms associated with the presence of asymmetric information.

The first empirical question in insurance markets can be summarized as follows: Is there any residual correlation between chosen insurance coverage and risk within risk classes? The second question is how to identify which information problem remains when the first test rejects the null hypothesis that there is no residual information problem. This step is important for the insurer because it must implement the appropriate instruments to improve resource allocation. A deductible efficiently reduces *ex ante* moral hazard, but not necessarily *ex post* moral hazard because often, the accident has already occurred when the action is taken. A high deductible can even have an adverse effect and encourage accident cost building (Dionne and Gagné, 2001). As is well known in the empirical literature, a positive correlation between insurance coverage and risk is a necessary condition for the presence of asymmetric residual information, but it does not shed light on the nature of the information problem. The third question is how improving the contracts can reduce the negative impact of asymmetric information on resource allocation. These resource allocation objectives must take into account other issues such as risk aversion, fairness, and accessibility of insurance. This last issue is particularly important in many insurance markets. A decrease in insurance coverage may reduce *ex ante* moral hazard because it exposes the insured person to risk, but it also significantly reduces accessibility to insurance protection for risky and poor people who are not always responsible for their risk type and financial conditions.

Econometricians analyze two types of information when studying insurers' data (Boyer and Dionne, 1989; Boyer, Dionne, Vanasse, 1992; Dionne and Vanasse, 1989, 1992; Chiappori, 1994; Puelz and Snow, 1994; Gouriéroux, 1999; Richaudeau, 1999; Dionne and Ghali, 2005; Dionne et al, 2006; Gouriéroux et al, 1984; Hausman et al, 1984; Pinquet, 1999, 2012; Saito, 2006). The first type contains variables that are observable by both parties to the insurance contract. Risk classification variables are one example. Econometricians/insurers combine these variables to create risk classes when estimating accident distributions. Observed variables can be used to make estimates conditional on the risk classes or within the risk classes. The second type of information is related to what is not observed by the insurer or the econometrician during contract duration and at contract renegotiations, but can explain the insured's choice of contracts or actions. If we limit our interpretation to asymmetric information (either moral hazard or adverse selection), we can test the conditional residual presence of asymmetric information in an insurer's portfolio; or look for a correlation between the contract coverage and the realization of the risk variable during a contract period. Two parametric tests have been proposed in the literature (Chiappori and Salanié, 2000; Dionne et al, 2001; see Chiappori and Salanié, 2003, 2012, for detailed analyses). One parametric test (Dionne at al. 2001) estimates the following relationship:

$$y_i = g\big(\alpha + \beta X_i + \gamma d_i + \delta E(d_i|X_i)\big) + \varepsilon_i, \qquad (1)$$

where y_i is the contract choice by individual i (level of deductible, for example), X_i is a vector of control variables such as the observable characteristics used in risk classification and control variables for risk aversion, β is a vector of parameters to be estimated, d_i is the realization of the random variable observed at the end of the contract period (accident or not, for example), $E(d_i|X_i)$ is the conditional expected value of the random variable obtained from the estimation of the accident distribution, and ε_i is the residual of the regression. A positive sign is usually anticipated for the coefficient of d_i (γ) when residual asymmetric information remains (higher coverage is related to more accidents or higher risk). The seminal theories of Rothschild and Stiglitz (1976) and Wilson (1977) strongly predict that such a correlation should be observed in the data in the presence of adverse selection, while Holmstrom (1979) and Shavell (1979) strongly predict that the correlation is due to moral hazard. Note that the dependent variable in the above regression can be the risk variable d_i while the coverage y_i is an independent variable. This symmetry is discussed in detail in Dionne et al (2006). The presence of the variable d_i is not necessarily exogenous in equation (1). It is often better to instrument this variable (See Dionne, St-Amour and Vencatachellum, 2009, Dionne, La Haye and Bergerès, 2010, and Rowell, 2011, for more details).

The presence of $E(d_i|X_i)$ is necessary to control for specification errors (missing variables) or for potential non-linearity not modeled in the equation. Without this control, the coefficient of d_i can be significant for reasons other than the presence of residual asymmetric information in the risk classes.

If the coefficient of d_i is not significant, one can reject the presence of residual asymmetric information in the risk classes when all other factors are well controlled. This does not mean that there is no asymmetric information in this market; rather, it means that the insurer's risk classification system eliminates asymmetric information efficiently, and that there is no *residual* asymmetric information within the risk classes. In other words, when risk classification is done properly, it is not necessary to choose the contract form within the risk classes to reduce asymmetric information.

An equivalent parametric model was proposed by Chiappori and Salanié (2000). Here, two equations are estimated simultaneously, one for contract choice and the other for accident distribution. An example is the bivariate probit model:

$$y_i = f(X_i, \beta) + \varepsilon_i \tag{2}$$

$$d_i = g(X_i, \beta) + \eta_i. \tag{3}$$

The test consists in verifying whether there is dependence between the residuals of the two equations. An absence of conditional correlation is interpreted as an absence of residual asymmetric information in the data. The authors present an additional non-parametric test that is independent of the functional forms of the above models. It is based on a Chi-square test of independence. However their test seems to be limited to discrete variables, contrary to the two parametric tests presented above. (See Su and Spindler, 2010, for a longer discussion).

Many extensions of these models were presented in the literature. Chiappori et al (2006) presents conditions to obtain robustness of the test when insured may have different degrees of risk aversion. They show that if insurers maximize profits in competitive markets, the results of the above test are robust to heterogeneity in preferences. Such robustness is less evident in non-competitive insurance markets.

Fang et al (2008) do not reject asymmetric information in the medical insurance market, but do not find evidence of adverse selection. Their results are consistent with multidimensional private information along with advantageous selection (de Meza and Webb, 2001). They obtain a *negative* correlation between risk and insurance coverage. Risk aversion is not a source of advantageous selection in their data. The significant sources are income, education, longevity expectations, financial planning horizons, and most importantly, cognitive ability, (See also Finkelstein and McGarry, 2006, on this issue).

To separate moral hazard from adverse selection, econometricians need a supplementary step. An additional market relationship can be estimated to look for adverse selection (conditional on the fact that the null hypothesis of no asymmetric information was rejected), as Dionne, St-Amour and Vencatachellum (2009) did for auctions. In insurance markets, dynamic data are often available. Time adds an additional degree of freedom to test for asymmetric information (Dionne and Lasserre, 1985, 1987; Dionne and Vanasse, 1989, 1992; D’Arcy and Doherty, 1990; Dionne and Doherty, 1994; Chiappori et al, 1994; Hendel and Lizzeri, 2003). This information can be used in many insurance markets where past experience information is available and when it is possible to use it. For ethical reasons, this information is not utilized on an individual basis in health insurance and for bodily injury insurance in many countries. Experience rating works at two levels in insurance. Past accidents implicitly reflect unobservable characteristics of the insured (adverse selection) and introduce additional incentives for prevention (moral hazard). Experience rating can therefore directly mitigate problems of adverse selection and moral hazard, which often hinder risk allocation in the insurance market.

Experience rating not only provides additional information on risk, but may also play an important role in the dynamic relationship between policyholders' insurance claims and contract choice. The theoretical literature on repeated insurance contracting over time clearly indicates that these features may help overcome problems of moral hazard when risks known to the policyholder (endogenous) are unobservable by the insurer (moral hazard, Winter, 2012) or when exogenous characteristics are unobservable (adverse selection, Dionne, Fombaron, Doherty, 2012). Contract choice is influenced by the evolution of the premium, which is closely linked to the insured's risk or past experience. Because increased insurance coverage tends to lower the expected cost of accidents for the insured, incentives for safe behavior are weakened for all risks. Under experience rating, the subsequent rise in accidents increases the marginal costs of future accidents when experience rating is taken into account. Experience rating may therefore offset the disincentive effect created by single-period insurance coverage.

The above empirical tests are conducted in a static framework, which fails to recognize the dynamics that experience rating introduces in contractual relationships. Chiappori and Salanié (2000) discuss in detail how the omission of the experience-rating variable, even in tests with one-period data, must plausibly explain the failure to detect asymmetric information.

Abbring et al (2003) apply a multi-period incentive mechanism by focusing on the dynamics of claims, but not on the dynamics of contract choice (because of data limitations). Proposing specific assumptions about the wealth effects of accidents to policyholders who differ only in their claim records (thus their experience rating), their model predicts that subjects with the worst claims records should try harder to increase safety, and thereby, ceteris paribus, file fewer claims in the future. However, their data do not support the presence of moral hazard. Dionne, Pinquet et al (2011) extend their model and do not reject the presence of moral hazard, using a different data set. The potential presence of adverse selection in their data was not a real problem because all drivers must be insured for bodily injuries (see also Abbring et al, 2008, and Rowell, 2011, for other tests of moral hazard).

Dionne, Michaud, and Dahchour (2011) show that failure to detect residual asymmetric information, and more specifically, moral hazard and adverse selection in insurance data, is due to the failure of previous econometric approaches to model the dynamic relationship between contract choice and claims adequately and simultaneously when looking at experience rating. Intuitively, because there are at least two potential information problems in the data, an additional relationship to the correlation between risk and insurance coverage is necessary to test for the causality between risk and insurance coverage. Using a unique longitudinal survey of policyholders from France, they propose a methodology to disentangle the historical pathways in claims and premiums. They show how causality tests can be used to differentiate moral hazard from asymmetric learning (and eventually adverse selection). They do not reject moral hazard for a given group of policyholders, and do not reject asymmetric learning for younger drivers. The empirical methodologies of Dionne, Pinquet et al (2011) and Dionne, Michaud, Dahchour (2011) are reviewed in detail below.

3. Ex ante Moral Hazard and Choices of Work Contracts

There is, by definition, ex ante moral hazard if one of the parties to a contract can affect the results of the contractual relation by non-observable actions before realization of the random variables (Holmstrom, 1979; Shavell, 1979; Caillaud et al, 2000) (see Arnott, 1992, and Winter, 2012, for reviews of the insurance literature with moral hazard). In the simple model that we shall now evaluate, the realized output is observable but we do not know whether its value is due to the agent's effort or to the outcome of a random variable. We thus have a problem of identification to solve, if we want to check for the presence of residual moral hazard.

One useful prediction that models with moral hazard have made for the labor market is that forms of compensation can influence work incentive: a worker paid based on performance should work harder than a worker paid an hourly wage. In other words, there should be less moral hazard when workers are paid based on performance, because their compensation is exposed to risks whose impact they can vary by their efforts.

Empirically, the hardest factor to measure in the model is the worker's effort, as this means gaining access to a variable the employer cannot observe, and which can still be used to see whether methods of compensation have any impact on effort. Foster and Rosenzweig (1993, 1994) used calories consumed by workers as an approximation of the effort they expend**.**

They propose a simple theoretical model of workers' health in which body mass (kg/square meter) is affected by food intake, illness, and work effort. They show that it is possible, for the types of jobs studied, to make a direct connection between forms of compensation and the calories consumed. More specifically, in periods where workers have access to methods of compensation that reward more high powered performance, they work harder and consume more calories, thus justifying the direct theoretical link between method of compensation and consumption of calories.

To test their model, they used panel data containing information on 448 farming families in the Philippines; the members of these families may work either for themselves or for outsiders, under different forms of compensation. These individuals were interviewed four times concerning their wages, their modes of compensation, the type of work done, and the quantity of calories consumed over the previous 24 hours. A period of four months separated the interviews.

The results from estimation of the health function indicate that self-employment and piece work significantly reduce the body mass index compared with unemployment, whereas work compensated on an hourly basis shows no significant effect. This seems to indicate either less effort or a measurable presence of moral hazard in those who are paid with an hourly rate.

What about the link between methods of payment and the performance rate per calorie consumed? They found that the calories consumed are associated with higher pay and performance in self-employment and piece work. Consequently, workers receiving these modes of payment consume more calories and, thus, can be said to work harder.

The next important question is: Is this a test for moral hazard or for adverse selection? In other words, do workers themselves choose their type of work and mode of compensation?

The authors tried to answer this question by checking whether their data contained any sample selection effect. They used two methods to do this: Heckman's two-step Probit selection (1979) and Lee's multinomial Logit selection (1983). Both models render identical results. It should be pointed out that 47.1% of the subjects worked under different regimes during the same period. However, this statistic does not suffice to qualify the choices as random, because only 28% worked for hourly wages in all four periods.

Taking workers' choices of types of compensation explicitly into account tends to strengthen rather than weaken the results. Modes of compensation actually have a bigger impact on the use of calories with the selection model. This implies that those who choose incentive pay at the margin do so because they truly want to work harder. Unlike what the authors suggest, the model tested is not a pure moral-hazard model. It is rather a mixed model containing aspects of adverse selection and moral hazard. The best physically endowed and most highly motivated will choose the highest paying but most demanding work.

In fact, to isolate a pure moral-hazard effect without dynamic data, it practically takes an exogenous change in a compensation regime or in some other parameter impinging on all the agents. We will now study changes of this nature as we turn to ex post moral hazard.

4. Ex post Moral Hazard, Demand for Medical Services, and Duration of Work Leaves

In our applications, ex post moral hazard deals with non-observable actions on the part of agents, actions that occur during or after the outcome of the random variable or accident (Townsend, 1979, and Gale and Hellwig, 1985). For example, an accident can be falsified to obtain better insurance compensation. This form of moral hazard is often associated with fraud or falsification (Crocker and Morgan, 1998; Crocker and Tennyson, 1999; Bujold, Dionne, and Gagné, 1997; Picard, 2000). Partial insurance of agents is not optimal in reducing this form of moral hazard, because agents often know the state of the world when they make decisions. Claims auditing is more appropriate, but it is costly, resulting in the potential presence of this moral hazard in different markets.

The main difficulty in isolating the ex post moral hazard effect in different levels of insurance coverage is separating the effects of price and income variations from the effects of asymmetric information. Contrary to what is often stated in the literature (especially that of health insurance), not every variation in consumption following a variation in insurance coverage can be tied to ex post moral hazard. When compared with full-coverage regimes, it is perfectly conceivable that a health insurance regime with partial coverage might be explained by transaction costs and patients' decision to curtail consumption of certain services because they must share the cost. If for some reason, the transaction costs drop and the insurance coverage expands, the consumption of medical services will increase, because their price will be cheaper. Yet this increase will not be due to moral hazard. It will simply be a classic effect of price on demand. There are still too many articles in the literature that confuse variations in demand with moral hazard (see, however, the discussion in Lo Sasso et al, 2010, and the contributions of Manning et al, 1987; Chiappori et al, 1998; Dionne and St-Michel, 1991; Lo Sasso et al, 2010).

Another big difficulty in isolating moral hazard is linked to the possibility that potential policyholders, who are better informed than the insurer about the state of their health over the next period of the contract, will make an endogenous choice of insurance regime. As a rule, those expecting health problems choose more generous insurance regimes, even if the per unit cost is higher. This is a well-known adverse selection effect.

In the famous Rand corporation study (Manning et al, 1987 and Newhouse, 1987) dealing with the effects of changes in insurance coverage on the demand for medical services, the experimental method used was capable of isolating the elasticity of the demand from the effects of adverse selection by random selection of families who might be subject to exogenous changes in insurance coverage but who were not free to choose their insurance coverage ex ante. They thus successfully calculated elasticities of demand much lower than those obtained in other studies that did not screen for the effect of endogenous choices of insurance regimes (adverse selection).

Their measurement of the elasticity of demand for medical services is not a measurement of ex post moral hazard. It is, in fact, very unlikely that there is any moral hazard in their data, considering the extensive screening done (see Dionne and Rothschild, 2011, for a longer discussion on health care insurance).

Let us now consider work accidents. As indicated above, using an exogenous change in an insurance regime can isolate moral hazard. An exogenous change in an insurance regime can be interpreted as a laboratory experiment, if certain conditions are met. Similar to studies of laboratory animals, it is possible to restrict choice sets: here we restrict the choices of insurance available to the subjects.

It is also important to have a control group who undergoes the same insurance changes, but who does not have the same information problems as those expected. For example, if we suspect that some workers with specific medical diagnoses (hard to diagnose and verify) have greater information asymmetry with the insurer, there have to be other workers having undergone the same insurance changes at the same time but whose information asymmetry is weaker (easy to diagnose and verify). The reason for this is that it is hard to isolate an absolute effect with real economic data, because other factors not screened for may lead to changes in behavior. The control group allows us to isolate a relative effect arising from the information problem, all things being equal. To simplify the analysis, it is preferable that the period under study should be short enough to avoid having to screen for several changes at once.

Dionne and St-Michel (1991) managed to bring together all these conditions in a study of change in coverage for salary losses associated with work accidents (see Fortin and Lanoie, 1992 and 2000, for similar studies and for a survey of different issues associated with workers' compensation; see also the recent survey of Butler et al, 2012).

The change in insurance coverage studied was exogenous for all the workers. Other forms of insurance were not readily available, even if, in theory, it is always possible to buy extra insurance in the private sector if one is not satisfied with the public regime. Very few individuals do so in Quebec for this type of compensation. The fact that there are state monopolies over several types of insurance coverage in Quebec makes it easier for Dionne and St-Michel (1991) to meet this condition.

Dionne and St-Michel (1991) showed, first, that the increase in insurance coverage had a significant positive effect on the duration of absence from work. This effect cannot be interpreted as being moral hazard; it may simply be associated with an increase in demand for days off due to their lower cost. Next, the authors checked to see whether this effect was significant only for diagnoses with greater information asymmetry (hard to diagnose) between the worker and the insurer as represented by a doctor. This second finding confirms that the only effect observed on the duration of absences was that of moral hazard, because the workers of the control group (those without information asymmetry, easy to diagnose) did not modify their behavior. In addition, the change-of-regime variable without interaction with diagnoses is no longer significant when the diagnosis-change-of-insurance variables are adjusted. This implies that there is no demand effect. However, the change of regime achieved the desired redistribution effects by allowing poorer workers to have access to more insurance.

Arguably, Dionne and St-Michel isolated an ex post moral hazard effect (see Cummins and Tennyson, 1996; Butler et al, 1996a; Ruser, 1998; Dionne, St-Michel and Vanasse, 1995; Butler and Worall, 1983, 1991; Krueger, 1990; Lanoie, 1991; Leigh, 1985; Meyer et al, 1995; Ruser, 1991; Thomason, 1993, for similar results). Nonetheless, it is highly unlikely that the change in regime studied had an impact on ex ante prevention activities that might affect the severity of work accidents. There is no reason to think that the average worker can practice selective prevention to influence diagnoses ex ante. Ex post, however, when workers know their diagnosis, they can take undue advantage of the situation of asymmetric information. Some workers might be more tempted to provoke accidents or to falsely claim that they had an accident to receive more compensation when the rates are more generous. These activities were not distinguished from other forms of moral hazard by Dionne and St-Michel, because they can be interpreted as ex post moral hazard.

It is also difficult to find the link between this result and adverse selection. On the one hand, workers could not choose their insurance coverage in this market and, on the other hand, it is highly unlikely that the change in insurance regime had any short-term effect on workers' choice of more or less risky jobs.

Fortin and Lanoie (2000) review the literature on the incentive effects of work accident compensation. They use the classification of different forms of moral hazard proposed by Viscusi (1992). The form of ex post moral hazard we just described is linked to the duration of claims, which they distinguish from moral hazard in the form of substitution hazard. This distinction can be explained, for example, by the fact that compensation for work accidents is more generous than that for unemployment insurance. Activities resulting in accidents are called causality moral hazard, which is ex post moral hazard (bordering on ex ante moral hazard), because the action takes place at the time of the accident. The result obtained by Dionne and St-Michel captures these three forms of ex post moral hazard. In fact, workers may have substituted workers' compensation for unemployment insurance.

To deepen the analysis, one must attempt to distinguish between the three forms of ex post moral hazard: incentives provoking hard-to-verify accidents; decisions to prolong length of absence in hard-to-check diagnoses; or decisions to substitute accident compensation for unemployment insurance, or even falsification. This distinction would be important because the mechanisms for correcting the situation would not necessarily be the same for each of these forms of asymmetric information.

The last three forms are difficult to distinguish, because they belong to the same market. However, it is possible to separate new accidents from older ones using indicative variables. We know, for example, that the accidents provoked occur early on Monday mornings (see also Fortin and Lanoie, 2000, and Derrig, 2002) and that, among seasonal workers, requests to extend work absences increase with the approach of unemployment insurance periods. Further research is needed on this subject.

5. Testing for moral hazard in the automobile insurance market[4]

5.1 Moral hazard as a function of accumulated demerit points

Below, I analyze moral hazard as a function of demerit points. Because no-fault environments are common in the North American continent, traffic violations are events likely to be used in experience rating schemes. Increases in premiums are often triggered by claims at fault in the vehicle insurance sector.

In Quebec, the public insurer in charge of the compensation of bodily injuries uses an experience rating scheme based on demerit points.[5] The same public enterprise is also in

[4] This section is based on Dionne, Michaud and Pinquet (2012).

charge of the point-record license system. Dionne, Pinquet et al (2011) show that the new insurance pricing scheme introduced in 1992 reduced the number of traffic violations by 15%. They also verified that there is residual *ex ante* moral hazard in road safety management. The discussion below focuses on the methodology they developed for obtaining this result.

The methodology extends the empirical model of Abbring et al (2003). Over time, a driver's observed demerit points informs on two effects: an unobserved heterogeneity effect and an incentive effect. Drivers with more demerit points accumulated during a period are riskier with respect to hidden features in risk distributions. Hence, unobserved heterogeneity is a form of risk reassessment in the sense that those who accumulate demerit points represent higher risks over time. This effect is in the opposite direction of the incentive effect. For the incentive effects, accumulating demerit points should increase the incentive for safe driving to reduce the probability of receiving a higher penalty. The time effect of unobserved heterogeneity is also converse to that of the incentive effect.

The model proposed by Dionne, Pinquet et al (2011) tests for an increasing link between traffic violations and the number of accumulated demerit points over time. Rejecting the positive link is evidence of moral hazard. They estimate the following hazard function (Cox, 1972):

$$\lambda_i(t) = \exp\left(x_i(t)\beta\right) + g\left(adp_i(t)\right) \times h\left(c_i(t)\right) \tag{4}$$

where $\lambda_i(t)$ is the hazard function for driver *i* at date *t*, $x_i(t)$ is a vector of control variables, β represents the corresponding coefficients, $adp_i(t)$ is the number of demerit points accumulated over the two previous years at time *t*, and $c_i(t)$ is contract time at date *t*.

[5] On point-record driver's license, see Bourgeon and Picard (2007).

In the absence of moral hazard, g should be increasing because of unobserved heterogeneity. They found that g is decreasing when drivers have accumulated more than seven demerit points. This means that beyond seven demerit points, drivers become safer if they do not lose their driver's license. This is evidence of the presence of moral hazard in the data: these drivers were negligent when the accumulated record was below seven demerit points.

5.2 Separating moral hazard from learning and adverse selection with dynamic data

To separate learning leading to adverse selection (asymmetric learning) from moral hazard, Dionne, Michaud et al (2011) consider the case where information on contracts and accidents is available for multiple years in the form of panel data. They exploit dynamics in accidents and insurance coverage controlling for dynamic selection due to unobserved heterogeneity. They construct two additional tests based on changes in insurance coverage. Coupled with the negative occurrence test of Abbring et al (2003) and Dionne, Pinquet et al (2011), these tests allow them to separate moral hazard from asymmetric learning (which should become adverse selection in the long run).

They analyze the identification of asymmetric learning and moral hazard within the context of a tractable structural dynamic insurance model. From the solution of their theoretical model, they simulate a panel of drivers behaving under different information regimes or data generating processes (with or without both moral hazard and asymmetric learning). They validate their empirical tests on simulated data generated from these different information regimes. They then apply these tests to longitudinal data on accidents, contract choice and experience rating for the period 1995-1997 in France (Dionne, 2001). They find no evidence of information problems among experienced drivers (more than 15 years of experience). For drivers with less than 15 years of experience, they find strong evidence of moral hazard but little evidence of asymmetric learning. They obtain evidence of asymmetric learning, despite the small sample size, when focusing on drivers with less than 5 years of experience. To obtain these results, they estimated the following model.

They consider a joint parametric model for the probabilities of accidents and contract choice. Each equation corresponds to a dynamic binary choice model with pre-determined regressors and an error component structure. The error component structure is important given the likelihood of serial correlation in contract and accident outcomes. They use the solution proposed by Wooldridge (2005) to take the potential left censoring effect into account.

More specifically, the process for accidents is specified as:

$$n_{it} = I(x_{it}\beta_n + \phi_{nd}d_{it-1} + \phi_{nn}n_{it-1} + \phi_{nb}b_{it} + \varepsilon_{n,it} > 0) \qquad (5)$$
$$i = 1,...,N, t = 1,...,T$$

where $\varepsilon_{n,it}$ has an error component structure $\varepsilon_{n,it} = \alpha_{ni} + v_{n,it}$, n_{it} is a binary variable for the number of accidents of individual *i* at time *t*, d_{it-1} is his contract choice in period $t-1$, n_{it-1} is his number of accidents in period $t-1$, and b_{it} is his bonus-malus score at period *t*. The presence of moral hazard would be confirmed by a positive sign for ϕ_{nd} (more insurance coverage-more accidents) and a negative sign for ϕ_{nb} (a higher malus creates more incentives for safe driving, similar to the test presented in the previous section with accumulated demerit points.) Here a high malus means an accumulation of accidents over the previous periods. They specify a similar equation for contract choice:

$$d_{it} = I(x_{it}\beta_d + \phi_{dd}d_{it-1} + \phi_{dn}n_{it-1} + \phi_{db}b_{it} + \varepsilon_{d,it} > 0) \qquad (6)$$
$$i = 1,...,N, t = 1,...,T$$

where again $\varepsilon_{d,it} = \alpha_{di} + v_{d,it}$. The asymmetric learning test is a test of whether an accident in the last period, conditional on the bonus-malus, leads to an increase in coverage this period. Drivers thus learn that they are riskier than anticipated and increase their insurance coverage accordingly. It is a test of whether $\phi_{dn} > 0$ or not.

6. Insurance Fraud

Insurance fraud (or ex post moral hazard) has become an important economic problem in the insurance industry (See Derrig, 2002, for a survey). Early empirical evaluations include the reports from the Florida Insurance Research Center (1991) and the Automobile Insurers Bureau of Massachusetts (1990), the contributions of Weisberg and Derrig (1991, 1992, 1993, 1995) and Fopper (1994) in the United States and the Dionne and Belhadji (1996), Belhadji et al (2000), and Caron and Dionne (1997) studies for the Insurance Bureau of Canada (Medza, 1999). As for ex ante moral hazard, insurance fraud does not necessary imply a criminal act. It ranges from simple buildup to criminal fraud (Picard, 2012).

Townsend (1979) studied the optimal contract form under a costly state verification setting. He obtains that a straight deductible is optimal under deterministic auditing while Mookherjee and Png (1989) do not obtain such a simple contract form when auditing costs are random. This last result is explained in part by the fact that random auditing introduces a supplemental source of uncertainty to the risk averse insured. Bond and Crocker (1997), Picard (2000), and Fagart and Picard (1999) extend this theoretical framework to insurance fraud, and design the optimal insurance contracting form when the policy holder can manipulate auditing costs. The optimal contract in not a straight deductible as is often observed in practice, and can have very complicated forms that may even be nonlinear (see Picard, 2012, for details and Hau, 2008, for the consideration of costly state verification and costly state falsification in a single model). Schiller (2006) asserts that the efficiency of audit could be improved through conditioning the information from the detection system under costly state verification. Interventions other than optimal contract design can be used by insurers for limiting insurance fraud. Dionne, Giuliano and Picard (2009) theoretically and empirically investigate the optimal audit strategies when the scoring methodology is used by insurers or when fraud signals (or red flags) serve to evaluate the probability that a file is fraudulent. Their results are related to the credibility issue of auditing that is also analyzed in detail in Picard (1996) and Boyer (2004) (see also Pinquet et al, 2007, on the use of fraud signals).

Lacker and Weinberg (1989) and Crocker and Morgan (1998) theoretically investigate optimal insurance contracting under costly state falsification by the insured. They obtain that the solution always involves some level of manipulation and the insurance payment includes overinsurance. Crocker and Tennyson (1999, 2002) have empirically tested the link between insurance fraud and optimal insurance contracting under costly state falsification.

Insurance fraud has been analyzed empirically in automobile insurance markets by, among others, Cummins and Tennyson (1996); Tennyson (1997); Abrahamse and Carroll (1999); Carroll and Abrahamse (2001); Bugold et al (1997); Dionne and Gagné (2001, 2002); Derrig et al (2002, 2006); Dionne and Wang (2011); Artis et al (2002); Brockett et al (2002); Pao et al (2012). Other researchers investigated the workers' compensation insurance market (Dionne and St-Michel, 1991; Butler et al, 1996) and the health care insurance market (Dionne, 1984; Hyman, 2001, 2002).

Derrig (2002), Artis et al (2002), Brockett et al (2002), Major and Riedinger (2002) Viaene et al (2002), Caudill et al (2005) and Loughran (2005) have also explored many techniques of fraud detection. Tennyson and Salsas-Forn (2002) investigated the concept of fraud detection and deterrence while Moreno et al (2006) verified how an optimal bonus malus scheme can affect the level of fraud.

The causes of the rapid growth of insurance fraud are numerous[6]: changes in morality, increased poverty, modifications in the behavior of the intermediaries (medical doctors or mechanics, for instance), insurers' attitudes, etc. (Dionne, 1984; Dionne, Gibbens and St-Michel, 1993, Bourgeon and Picard, 2012) and variation of economic activity (Dionne and Wang, 2011). In two articles, Dionne and Gagné (2001, 2002) highlight the nature of insurance contracts. In both cases, they use the theoretical model proposed by Picard (1996) to obtain equilibrium without the parties' commitment. In the 2002 article, they test whether the presence of a replacement cost endorsement can be a cause of fraudulent

[6] For a recent analysis of insurance fraud in the unemployment insurance market, see Fuller et al, 2012.

claims for automobile theft. This endorsement was introduced in the automobile insurance market to increase the insured's protection against depreciation.

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 partial with respect to the market value of a new automobile. A replacement cost endorsement covers the cost of a new 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 asymmetric information, this type of contract can be optimal. The only major difference with standard insurance contracts is the higher expected coverage cost, which can easily be reflected in the insurance premium.

Intuitively, a replacement cost endorsement may decrease the incentives toward self-protection because 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 because it occurs when an opportunity occurs and usually not when an insurance contract for a new vehicle is signed. Alternatively, under adverse selection, individuals may choose to include a replacement cost endorsement in their coverage because they know they will be more at risk.

The first objective of the study by Dionne and Gagné (2002) was to test how the introduction of a replacement cost endorsement affects the distribution of thefts in the automobile insurance market. Another significant objective was to propose an empirical procedure allowing the distinction between the two forms of moral hazard. In other words, they 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. They also took into account the adverse selection possibility because the insured ex ante decision to add a replacement cost endorsement to the insurance policy might be explained by unobservable characteristics that also explain higher risks.

As discussed above, Dionne, Gouriéroux and Vanasse (2001, 2006) proposed a parametric model that was applied to test for the presence of asymmetric information. In their article, Dionne and Gagné (2002) extend this method to consider both forms of moral hazard simultaneously. Their approach also makes it possible to isolate adverse selection.

Let us first consider *y*, an endogenous binary variable indicating the occurrence of a theft. The decision or contract choice variable *z* (in this 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 $\boldsymbol{x}$ coincides with that based on $\boldsymbol{x}$ alone. Under this condition, the conditional distribution of *y* can be written as

$$\varphi_y(y \mid \mathbf{x}, z) = \varphi_y(y \mid \mathbf{x}), \tag{7}$$

where $\varphi(\bullet \mid \bullet)$ denotes a conditional probability density function. A more appropriate but equivalent form for different applications is

$$\varphi_z(z \mid \mathbf{x}, y) = \varphi_z(z \mid \mathbf{x}). \tag{8}$$

In that case, the distribution of *z* is estimated and when condition (8) 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, because (7) and (8) are equivalent. The empirical investigation of Dionne and Gagné (2002) relies on the indirect characterization as defined by (8). It can be interpreted as the description of how individuals' decisions affect their future risks (moral hazard) or of what their decisions would be if they knew their future risks (adverse selection).

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 $\boldsymbol{x}$ and *y*, that is:

$$\varphi_z(z \mid x, y) = \varphi_z(z \mid x'a + by).$$

This practice may induce spurious conclusions, because it is difficult to distinguish between the informational content of a decision variable and an omitted nonlinear effect of the initial exogenous variables. A simple and pragmatic way of taking these potential nonlinear effects of ***x*** into account is to consider a more general form:

$$\varphi_z(z \mid x, y) = \varphi_z(z \mid x'a + by + cE(y \mid x)), \tag{9}$$

where $E(y \mid x)$ is an approximated regressor of the expected value of *y* computed from the initial exogenous information. Assuming normality, $E(y \mid x)$ 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 (8) to hold may allow a distinction between different types of information problems depending on how *y* is defined. Dionne and Gagné (2002) defined *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, they identified the different types of information problems: adverse selection, ex ante moral hazard and ex post moral hazard or opportunistic fraud.

If a pure adverse selection effect exists, the time dimension (that is, the proximity of the expiration of the replacement cost endorsement in the contract, which is valid for only two years new car is bought) would be irrelevant. In other words, the effect of pure adverse selection would be significant and of approximately the same size regardless of the age of the contract. However, the effects may not be of the same magnitude.

Therefore, with a pure adverse selection effect, condition (8) should not hold in all sub-samples considered (i.e. $s = 1, 2, 3$ and 4).

Assuming that the same self-protection activities are involved in the reduction of the probabilities of both types of theft (partial and total), condition (8) 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, because 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 (8) does not hold in all sub-samples considered, but has 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).

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 (8) should hold in both sub-samples 1 and 2. Also, because the benefits of fraud for total theft are few at the beginning of the contract but increasing over time with a replacement cost endorsement, condition (8) 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 (8) would not be verified in sub-sample 4.

Dionne and Gagné’s (2002) empirical 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 insignificant at both the beginning of the contract and during the middle stage.

As suggested by Chiappori (1999), one way to separate insurance problems from claim data is to use a dynamic model. The data of Dionne and Gagné (2002) did not allow them to do so. The originality of their methodology, although in the spirit of Chiappori (1999), was to use different contracting dates for the replacement cost endorsement but claims over one period. Consequently, Dionne and Gagné (2002) were first able to separate moral hazard from adverse selection because the latter should have the same effect at each period according to the theory. They distinguished the two forms of moral hazard by using partial and total thefts and by assuming that the same preventive actions affect both distributions. Their results do not reject the presence of opportunistic fraud in the data, which means that the endorsement has a direct significant effect on the total number of car thefts in the market analyzed.

More recently, Dionne and Wang (2011) extended their methodology to analyze the empirical relationship between opportunistic fraud and business cycle (Boyer, 2001). They find that residual opportunistic fraud exists both in the contract with replacement cost endorsement and the contract with no-deductible endorsement in the Taiwan automobile theft insurance market. They also show that the severity of opportunistic fraud is counter-cyclical. Opportunistic fraud is stimulated during periods of recession and mitigated during periods of expansion.

To respond to the view of Picard (1996) and Schiller and Lammers (2010) that individuals' characteristics could affect the incentive to engage in fraud, Huang, Tzeng, and Wang (2012) find that individuals who properly maintain their vehicles do not commit opportunistic fraud induced by the replacement cost endorsement. This conclusion is robust regardless of whether they consider the endogeneity problem for maintenance behavior and of the threshold used to define proper car maintenance.

In their 2001 article, Dionne and Gagné discuss the effect of a higher deductible on the costs of claims explained by falsification. Since the significant contribution of Townsend (1979), an insurance contract with a deductible has been described as an optimal contract in the presence of costly state verification problems. To minimize auditing costs and guarantee insurance protection against large losses to risk-averse policy-holders, this optimal contract reimburses the total reported loss less the deductible when the reported loss is above the deductible, and pays nothing otherwise. The contract specifies that the insurer commits itself to audit all claims with probability one. This deductible contract is optimal only for the class of deterministic mechanisms. Consequently, we should not observe any fraud, notably in the form of build-up, in markets with deductible contracts, because the benefits of such activity are nil. However, fraud is now a significant problem in automobile insurance markets for property damage where deductible contracts prevail.

The recent literature on security design has proposed extensions to take into account different issues regarding the optimal insurance contracts. Three main issues related to the empirical model of Dionne and Gagné (2001) are discussed in this literature. First, the deductible model implies that the principal fully commits to the contract in the sense that it will always audit all claims even if the perceived probability of lying is nil. It is clear that this contract is not renegotiation proof: at least for small claims above the deductible, the insurer has an incentive to save the auditing cost by not auditing the claim. However, if the clients anticipate that the insurer will behave this way, they will not necessarily tell the truth when filing the claim!

One extension to the basic model was to suggest that random audits are more appropriate to reduce auditing costs. However, the optimal insurance contract is no longer a deductible contract and the above commitment issue remains relevant. Another extension is to suggest that costly state falsification is more pertinent than costly state verification for insurance contracting with ex post moral hazard. The optimal contract under costly state falsification leads to insurance overpayments for small losses and under-compensation for severe accidents. We do not yet observe such contracts for property damage in automobile insurance markets, although they seem to be present for bodily injuries in some states or provinces (Crocker and Tennyson, 1999, 2002).

The empirical hypothesis of Dionne and Gagné (2001) is as follows: when there is a sufficient high probability that the fraud will succeed, the observed loss following an accident is higher when the deductible of the insurance contract is higher. Because they have access to reported losses only, a higher deductible also implies a lower probability of reporting small losses to the insurer. To isolate the fraud effect related to the presence of a deductible in the contract, they introduce some corrections in the data to eliminate the potential bias explained by incomplete information.

Their results are quite significant. They imply that when there are no witnesses (other than the driver and passengers) on the site of the accident, the losses reported to the insurance companies are between 24.6% and 31.8% higher for those insured with a $500 deductible relative to those with a $250 deductible. Furthermore, they are confident that this increase corresponds to build-up, because their result is closely related to the presence of witnesses. Given the mean loss reported in their sample of $2552.65, the corresponding increases in the reported losses range from $628 to $812, which is far more than the difference between the two deductibles ($250). Thus, it seems than when insured decide to defraud, not only do they try to recover the deductible, but also to increase their net wealth.

The choice of deductible is arguably the consequence of an extension of the traditional adverse selection problem because the insured anticipates higher expected losses. However, if this ex ante argument were right, we should observe a significant effect of the deductible on reported losses even when the presence of witnesses is more likely, which was not the case. It would be surprising to obtain such an ex ante effect only in the case of accidents without witnesses, because it is difficult to anticipate the type of accident and its severity when choosing the deductible ex ante.

Insurers may also affect the probability of successful falsification by increasing the frequency of audits in the case of claims for which no witnesses are involved and for which the policy bears a high deductible. In other words, insurers may use the presence of witnesses as a fraud indicator. In this case, the results show that insurers are not fully efficient in their investigations because there is still a significant effect associated with the deductible in the reported loss equation. This interpretation is supported by the fact that insurers detect only 33% of fraud when they audit (Caron and Dionne, 1997).

Other contributions (Crocker and Morgan, 1998; Crocker and Tennyson, 2002) show that other types of contracts are more effective than deductible contracts in reducing this type of ex post moral hazard when falsification activities are potentially present. However, they limit the insurer's behavior to full commitment. The full characterization of an optimal contract in the presence of ex post moral hazard is still an open question in the literature (see Picard, 2012, for more details).

7. Adverse Selection and the Quality of the Transaction in a Market

Akerlof (1970) was the first to propose a model with asymmetric information on the quality of products. This groundbreaking article has motivated many researchers to study second-hand markets for durable goods. In general, owners of used goods know the quality of their good better than a potential buyer does. Kim (1985) proposed a model suggesting that traded used cars should be of higher quality. Bond (1982) tested a similar proposition but did not find evidence of adverse selection in the market for used pickup trucks. However Lacko (1986) reported evidence for older cars only, a result also obtained by Genesove (1993).[7] Below, Genesove's paper is reviewed in detail.

The main hypotheses related to testing for the presence of adverse selection are:

- During the transaction, one party is better informed than the other about the product's quality: usually the seller.
- Both of the parties involved in the transaction value quality.
- The price is not determined by either party but by the market.
- There is no market mechanism such as guarantees or reputation to eliminate adverse selection.

To test for residual adverse selection, Genesove (1993) analyzed the market for used cars sold by auction in the United States, where buyers have only a few moments to look at

[7] On double-sided adverse selection in the presence of insurance, see Seog (2010); on adverse selection in the labor market, see Greenwald (1986).

the cars and cannot take them for a test drive before purchase. The auction is simple: a series of ascending bids where the seller has the option of accepting or rejecting the second highest bid. Sixty per cent of the sellers agree to relinquish their cars. The auction lasts one minute and a half, including the time to put the car up for auction and the time to remove it once the last bid is made! As a rule, the second price should correspond to the average quality of the cars offered, and buyers are supposed to be aware of this level of quality.

Genesove wanted to test whether any observable characteristic of the seller could be used to predict the average quality of the cars sold. In the presence of perfect information on the quality of the product, the seller's characteristics would be of no importance. Only the quality of the product would count in explaining the price equilibrium.

He thus considered two types of sellers participating in these auctions: those who sold only used cars (UC) and those who sold both used and new cars (NC). Each seller participates in two markets: the auction market where the buyer makes no distinction in quality and a more traditional market where the real quality is more likely to be observed by the buyer.

It can be shown that the equilibrium price will be equal to the price matching the average quality each type of seller will offer. Thus, a seller whose cars are of superior quality to the average quality offered by this type will not put them up for auction unless there is a surplus in stock. In this case, it may offer some for auction, starting with those of lower quality. Moreover, the average quality of the two types may vary, because sellers may have different stock management systems. The author shows that those who offer the two types of cars (used and new) have cars whose average quality is higher.

The motive behind stock management is important in finding an equilibrium. If the only motive for putting used cars up for auction is to take advantage of information asymmetry as shown in Akerlof's model, it is hard to obtain an equilibrium in a market where buyers are ready to pay for average quality and sellers are motivated to offer cars of only inferior or average quality. However, during a period of surplus stock, some sellers may have cars worth less than market value that they may be motivated to sell at the average-quality price, to gain a bonus. In other words, buyers in this type of market would have to value cars more highly than sellers to obtain equilibrium. Gibbons and Katz (1991) have used this type of argument to obtain equilibrium in the work market with specific human capital. They argue, however, that this equilibrium can be explained either by adverse selection or by learning of the participants in the market.

Empirically, according to Genesove (1993), a positive bonus in an auction market is possible only in a situation of asymmetric information where the buyer pays the average-quality price associated with the type of seller. Thus a seller who is more likely to sell in this market because he often has surpluses will usually sell better quality cars and obtain, at the equilibrium, a higher average price for the same quality of car.

The author finds that, though the data covered cars from 1988 to 1984 and earlier, there is a significant bonus only for 1984 cars. He consequently concludes that residual adverse selection is weak in this kind of market. Hence, enough information circulates by other mechanisms, i.e. reputation and guarantees, to reduce the informational bonus to zero. Sellers are not truly anonymous in the auction market. The seller must be present to accept or refuse the second price. There are also limited guarantees protecting buyers during the first hour following the auction. As in the automobile insurance example, in Section 2, private markets use effective mechanisms to reduce residual adverse selection.

Many extensions have been presented in the literature. We discuss four of them. The first one proposes to use price and quantity profiles over time across brands of cars to isolate evidence of adverse selection (Hendel and Lizzeri, 1999). There will be evidence of adverse selection if the car that has a steeper price decline over time also has lower trade volume. This contrasts with the depreciation story, where the faster price decline should correspond to a larger volume of trade. The second extension is to show that leasing can solve the lemons problem (Guha and Waldman, 1996; Hendel and Lizzeri, 2002).

The next two extensions go back to the methodology to distinguish adverse selection from other information problems in these markets. As Dionne, St-Amour and Vencatachellum (2009) argue, information asymmetry is a necessary prerequisite for testing adverse selection. Otherwise a statistical relationship can be interpreted as a learning phenomenon or any other market relationship. Dionne, St-Amour and Vencatachellum (2009) apply a sequence of tests to Mauritian slave auctions to separate adverse selection from learning.

Information asymmetry is a necessary condition for adverse selection to take place. If information is asymmetric, then adverse selection is possible, but remains to be proven. This suggests a sequential procedure whereby information asymmetry is tested before adverse selection. Dionne, St-Amour and Vencatachellum (2009) apply this procedure in the particular context of nineteenth century Mauritian slavery. They ask (i) how the behavior of better informed bidders might have affected that of the less informed slave auction participants and (ii) what the impact of such inter-dependent bidding on slave prices would have been. If the second effect is negligible, then information was either symmetric or it was asymmetric but inconsequential. In contrast, if information is found to be asymmetric, then adverse selection is possible and additional tests can be performed.

To test for adverse selection after having verified the presence of asymmetric information in succession auctions using equation (1), the authors compare prices in succession sales with those in voluntary auctions. Again controlling for observable characteristics as well as the presence of informed bidders, they obtain that the succession sale premium is positive and statistically significant, meaning that adverse selection is present because the presence of asymmetric information was already proven in the succession market.

Another contribution of Dionne, St-Amour and Vencatachellum (2009) to the literature on the asymmetric information test is to verify if the independent variable of interest (d_i) in equation (1) is correlated with the unobservable factors. If this correlation exists, ordinary least square estimates may be biased. One way to reduce potential bias is to instrument the variable by adding exogenous variables to the vector of explanatory variables and by using the 2SLS method of estimation for the two equations. They used an instrument that reduces the potential bias but could not test the exogeneity of the instrument because they had only one instrument.

More recently, Dionne et al (2010) extended the above analysis using three instrumental variables. Their application tests the influence of information asymmetry between potential buyers on the premium paid for a firm acquisition. They analyze mergers and acquisitions as English auctions. The theory of dynamic auctions with private values exclusively predicts that more informed bidders should pay a lower price. They test that prediction with a sample of 1,026 acquisitions in the United States between 1990 and 2007. They hypothesize that blockholders of the target's shares are better informed than other bidders because they possess privileged information. Information asymmetry is shown to influence the premium paid, in that blockholders pay a much lower premium than do other buyers.

To obtain this result, they estimate the influence of determinants of the premium identified in the literature using the ordinary least squares method. Their model is expressed as in equation (1). Again the test for the null hypothesis of no information asymmetry is that the gamma is not statistically significant. The instrumental variables must be correlated with $Blockholders_i$ rather than with the error term in (1).

The three variables to instrument the presence of blockholders in the target are: 1) Intrastate; 2) Regulated industry; 3) An interaction variable between Intrastate and performance of the target. As pointed out above, these three variables must be correlated with the probability that blockholders are present in the auction but should neither directly affect the premium nor be correlated with the residuals of the premium equation. Because three instruments are examined, the authors can apply two formal tests to verify the desired result: the Sargan test for the over-identifying restrictions (the instruments are truly exogenous) and the Durbin-Wu-Hausman test for the relevance of instrumental variables method (or the endogeneity test).

They obtain that the presence of blockholders influences the equilibrium price of an acquisition and that their three instruments are exogenous and significant to explain the presence of blackholders.

8. Conclusion

We have explored the difficult question of the empirical measurement of the effects of information problems on the allocation of resources. The problems drew our attention: moral hazard, asymmetric learning, and adverse selection.

One conclusion that seems to be accepted by many authors is that information problems may create considerable distortions in the economy, in contrast with a situation of full and perfect information. Indeed, effective mechanisms have been established to reduce these distortions and to eliminate residual problems at the margin. In this new version of our survey, we have emphasized the role of dynamic data to identify different information problems. We have shown that dynamic data can be used to separate unobserved heterogeneity from moral hazard and to apply causality tests to separate moral hazard from adverse selection and asymmetric learning.

This conclusion seems stronger for adverse selection than for moral hazard, at least in the markets studied. One possible explanation, which should be investigated in detail, is that adverse selection concerns exogenous factors, whereas moral hazard and asymmetric learning hinge on endogenous actions that are always modifiable.

Finally, given the specific nature of the problems studied—lack of information—conclusions must be drawn prudently, because the effect measured cannot be fully verified. There will always be a lingering **doubt**!

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