Assurances

Assurances

TOWARDS AN ECONOMIC THEORY OF THE LIMITS OF INSURABILITY

Christian Gollier

Volume 68, numéro 4, 2001

URI : https://id.erudit.org/iderudit/1105340ar
DOI : https://doi.org/10.7202/1105340ar

Aller au sommaire du numéro

Éditeur(s)

HEC Montréal

ISSN

0004-6027 (imprimé)
2817-3465 (numérique)

Découvrir la revue

Citer cet article

Gollier, C. (2001). TOWARDS AN ECONOMIC THEORY OF THE LIMITS OF INSURABILITY. *Assurances*, *68*(4), 453–473. https://doi.org/10.7202/1105340ar

Résumé de l'article

Dans une économie concurrentielle à la Arrow-Debreu, les risques sont efficacement partagés à l'équilibre. Ce résultat bien connu se trouve en contradiction avec l'observation que beaucoup de risques ne sont en réalité pas assurés, tandis que d'autres sont couverts par des mécanismes hors marché. Dans cet article, nous proposons une synthèse des différents éléments de la littérature économique qui expliquent les limites de l'assurabilité. En plus des coûts de transaction, de la sélection adverse et du risque moral (ex ante et ex post), nous examinons des arguments basés sur la taille des risques, sur les faibles probabilités, sur la responsabilité limitée, sur les probabilités ambiguës et sur certains aspects dynamiques de la gestion des risques.

Assurances, volume 68, numéro 4, janvier 2001, 453-474

TOWARDS AN ECONOMIC THEORY OF THE LIMITS OF INSURABILITY

by Christian Gollier

ABSTRACT

In an Arrow-Debreu economy, all risks are shared efficiently at equilibrium. This result is in contradiction with the fact that many risks are not insured, and that others are covered only through a non-market system. This is the case for many risks associated to environment, technology, human capital. In this paper, we review the different arguments that have been developed during the last twenty years by economists to explain the limits of insurability by competitive markets. In addition to transactions costs, adverse selection and (ex ante and ex post) moral hazard, we examine arguments based on the size of losses, on low probabilities, on limited liability, on ambiguity and on some dynamic aspects of risk management.

Keywords: Insurability, regulation of insurance, catastrophic risk, environmental risk, social security.

RÉSUMÉ

Dans une économie concurrentielle à la Arrow-Debreu, les risques sont efficacement partagés à l'équilibre. Ce résultat bien connu se trouve en contradiction avec l'observation que beaucoup de risques ne sont en réalité pas assurés, tandis que d'autres sont couverts par des mécanismes hors marché. Dans cet article, nous proposons une synthèse des différents éléments de la littérature économique qui expliquent les limites de l'assurabilité. En plus des coûts de transaction, de la sélection adverse et du risque moral (ex ante et ex post), nous examinons des arguments basés sur la taille des risques, sur les faibles probabilités, sur la responsabilité limitée, sur les probabilités ambiguës et sur certains aspects dynamiques de la gestion des risques.

Mots clés : *Assurabilité, réglementation de l'assurance, risque catastrophique, risques environnementaux, sécurité sociale.*

The author :

Christian Gollier is professor of economics, GREMAQ and IDEI, University of Toulouse.

Financial Support from the Chair of Insurance of the FFSA at IDEI is acknowledged.

1. INTRODUCTION

The standard economic model of risk exchanges predicts that competition on insurance markets leads to a Pareto-efficient allocation of risks in the economy. In particular, it states that all diversifiable risks in the economy will be washed away through mutual risk-sharing arrangements. All risks will be pooled in financial and insurance markets. Moreover, the residual systematic risk in the economy will be borne by the agents who have a comparative advantage in risk management, as insurers and investors. In short, it means that all risks are insurable. This prediction is obviously contradicted by casual observations. Many diversifiable risks are still borne by individuals. Indeed, individual consumption levels are not perfectly correlated in the population, i.e., for every shock in the economy, there are "winners" and "losers". This is symptomatic of an inefficient risk sharing ex ante. To illustrate, most of the risks related to human capital, as long-term unemployment and fluctuations to labor incomes, cannot be insured. Many environmental, catastrophic and technological risks are not covered by an insurance contract.

The adverse consequences of the limits to insurability are overwhelmingly underestimated. The management of risks and the management of production cannot be disentangled. It forces small entrepreneurs to bear the risk linked to their investment. It yields a reduction in investment, employment and growth. In addition, the inability of our economies to efficiently transfer risks affecting human capital forces households to bear a larger risk over their lifetime. Given risk aversion, it has a dramatic adverse effect on welfare.

The possibility to transfer a risk on the market place is contingent upon whether the buyer is ready to pay a larger price than the minimum price at which the seller is ready to sell. Consequently, the concept of a limit to insurability cannot be defined only on the distributional characteristics of the risk, but it should also take into account the economic environment. Berliner (1982) enumerates the criteria to define insurability. The actuarial view on this problem is usually summarized by stating that a risk is insurable if the Law of Large Numbers is at work. It means that the maximum potential loss may not be infinite, or very large. Similarly, risks should not be too much positively correlated. In addition, it means that insurers should not accept risks with a too low probability of occurrence. Also, the risk must exist: a realized risk cannot be insured. The legal environment must be stable, or predictable. Finally, an objective distribution function can be estimated.

This definition is not entirely satisfactory. As said before, a transaction on the market is possible if the two parties are willing to transfer the underlying "good" against a specific price. This joint willingness can exist only if the seller and the buyer find it advantageous to exchange. We define a risk as being uninsurable if, given the economic environment, no mutually advantageous risk transfer can be exploited by the consumers and the suppliers of insurance. Partial uninsurability occurs when the parties can exploit only part of the mutually advantageous transfer of risk. Whether there exists a mutually advantageous risk exchange between the two parties is an interesting question that has been examined by several authors as Arrow (1965), Borch (1960), Raviv (1979) and Aase (1993). The basic model is a perfect competitive insurance market in which it clearly appears that indeed the Law of Large Numbers plays an important role to evaluate the social surplus of the transfer of risks. But, contrary to the standard actuarial view, the maximum potential loss and the probability of loss have an ambiguous effect on the size of the transfer of risk at equilibrium. In addition some factors as the degree of risk aversion of the agent , or her degree of optimism, are crucial in the insurability of risks in the economy.

The actuarial view on the limits of insurability appears to be too narrow. After all, the Lloyd's accepted to underwrite the risk of the capture of the monster of Loch Ness, and more standard insurance companies cover the risk of failure of Ariane V, the new European satellite launcher on which no data is available. Moreover, many risks on which the Law of Large Numbers could be used are beyond the limits of insurability. One cannot find insurers that would accept the risks of the absence of promotion, or of divorce.

The objective of this paper is to provide some insights on the recent developments on the economic analysis of the limits of insurability. There is no unified theory for it. Rather, there are a large set of economic reasonings explaining why some risks cannot be insured on the marketplace. All of them are related to a modification of one of the assumption in the Arrow-Borch standard model of perfect competition on insurance markets. Perfect competition is indeed a poor assumption for describing the insurance sector. First, it has long been recognized that the existence of asymmetric information is central to its functioning. Adverse selection and moral hazard can explain why competitive insurance markets fail to provide an efficient level of insurance. Specialists in this field focused their research in the recent years to the problem of insurance fraud, a special case of moral hazard. The risk of fraud is another explanation for the reluctance of insurers to provide coverage for some

risks. The effects of asymmetric information on the functioning of insurance markets are examined and measured in Dionne (2000). We also look to the limited liability rule which introduces another distortion in the form of negative externalities to victims.

We also provide some insights about the well-known uninsurability problem due to the fact that some risks may not have an objective probability distribution. The ambiguity of the distribution seems to be the rule rather than the exception in our fast-moving, heterogeneous world. We also look at the dynamic aspects of insurance contracts.

In section 2, we reexamine the standard Arrow-Borch model of perfect competition on insurance markets. In the following sections, we show how the modification of any of the assumption of the standard model can explain some forms of uninsurability. We provide some proposals to improve market efficiency.

2. THE CLASSICAL MODEL OF EFFICIENT RISK SHARING

Economists[1] have developed during the last thirty years a canonical model to deal with optimal insurance/risk-sharing and risk prevention. Our aim in this section is to review the assumptions and basic results of this simple model.

In the classical risk-sharing model, there is a large number of agents in the economy. Each agent has a risky endowment. Correlation among these risks is allowed. Agents are expected-utility maximizers, with an increasing and concave utility function. The following assumptions are made:

- There is no transaction cost.
- The distribution function of risks is common knowledge.
- The distribution function can depend upon prevention efforts by the agents. Efforts are observable at no cost.
- Losses are observable at no cost.
- There is full liability.
- The model is static, or there exists a complete set of insurance markets for future risks.

Under these conditions, we obtain the following well-known results:

- There will be a complete set of contingent markets. Agents will exchange bundles of state-contingent contracts that can be analyzed as an insurance contract. Competitive markets generate a Pareto-efficient allocation of risks in the economy in the sense that there exists no other feasible allocation of risks that would increase the expected utility of an agent without reducing the expected utility of at least another agent. This allocation will satisfy the mutuality principle which states that everyone's final wealth depends only on the aggregate wealth of the economy in the corresponding state. Namely, if there are two states of nature with the same aggregate wealth, the distribution of wealth among agents will be the same in the two states. This guarantees that all diversifiable risks are washed away. In particular, if there is no systematic risk in the economy, the aggregate wealth is certain, and by the mutuality principle, so will be the individual wealth levels. If a systematic risk exists, its sharing in the population satisfies a simple risk-sharing rule: the sensitivity of an individual's final wealth to the aggregate wealth in the economy is inversely proportional to its Arrow-Pratt degree of absolute risk aversion. In particular, if there is a risk-neutral agent in the economy, she will bear 100% of the systematic risk, thereby fully insuring the population.[2]
- Despite risks depend upon efforts to prevent them, there is no moral hazard problem. Indeed, since efforts are observable, each party will condition the acceptance of the contract to strict requirement on risk prevention by the other party. Contractors will privately trade-off their cost of effort to the benefits of risk-sharing generated by the contract. For example, an insurer will provide a better premium rate to those entrepreneurs who accept to invest in fire sprinklers in their buildings. The competitive equilibrium yields a socially efficient level of risk prevention. To illustrate the idea, if there is no systematic risk, or if there is a risk-neutral agent in the economy, at equilibrium a 1 euro increase in prevention effort by any agent generates a 1 euro increase in expected aggregate wealth in the economy.

We conclude that in the classical problem of insurance and risk prevention, there is no need for public intervention. Risk are

efficiently spread in the economy. This means in particular that agents are fully insured if risks are diversifiable, or if there exists a risk-neutral agent in the economy. Also, agents get the good incentives to invest in a socially efficient level of risk prevention. These results do not fit with the real world. In the next sections, we review the reasons why the classical model fails to explain why some risks are not insurable, or why the level of risk prevention is often not efficient.

3. TRANSACTION COSTS AND UNDIVERSIFIABLE RISKS

The prevalence of transaction costs in the insurance industry is a well-established fact. For many insurance lines like automobile insurance, transaction costs amount up to 30% of the premium. They correspond to general administrative costs, the cost of capital, the cost of marketing, the cost of claim-adjustment and court costs. Taxes are also an important source of transaction costs. These costs are eventually passed on to the policyholder through a loading on the premium.

How do transaction costs affect the insurability of risks? There is no doubt that some individuals with a low degree of risk aversion will find these costs too expensive with respect to the benefit of the coverage. In fact, Mossin (1968) proved that it is never optimal to purchase full insurance when the premium contains a proportional loading. Thus, transaction costs is a source of partial uninsurability.

More interestingly, Arrow (1965) showed that the optimal form of insurance contract is a contract with full insurance above a straight deductible if the loading only depends upon the actuarial value of the contract, i.e. the expected indemnity. Deductible insurance is a best compromise between the willingness to cover larger risk and the objective to limit transaction costs. The intuition is that the willingness to pay for coverage depends upon the variance of losses. When one reduces the size t of the risk, the willingness to pay for insurance decreases as t^2,[3] whereas deadweight transaction costs decrease as t. It implies that only large risks are insured. This is in contradiction with the observation that one has no problem to find insurance against cracks in one's windshield, but one cannot find insurance against much larger risks as long-term unemploy-

ment. We conclude that the existence of transaction costs is not a convincing explanation for insurance market failures for large risks.

The above argument holds specifically in the classical expected utility model. This model has been challenged for two decades by some economists and psychologists on the basis that it is only an approximation of households' attitudes toward risk. For example, Kahneman and Tversky (1979) performed experiments that tended to establish that people are much more affected by losses than by gains in wealth. That "loss aversion" should raise the demand for insurance, thereby making the transaction costs argument as a source of uninsurability even less credible.

One can link the argument of transaction costs to the one on undiversifiable risks. Obviously, many natural, environmental or technological risks are in the class of large risks that are difficult to eliminate by using the mutuality principle. Moreover, insurance companies will not provide fair insurance premiums for these risks. Indeed, shareholders will not be able to diversify the risk associated to the dividends paid by insurance companies that cover these large risks. They will ask for a risk premium, which will increase the cost of capital of these companies. This cost will be passed on to policyholders through a larger premium rate for the component of individual risks that is systematic. It will induce them to retain part of their individual risk. In short, the fact that the risk is systematic induces insurance premiums to contain a positive loading that has an effect equivalent to a transaction cost. This is the logic behind larger deductibles for systematic risks.

Still, the fact that many environmental and technological risks have a systematic component does not explain the observation that they are often entirely retained by the initial risk-bearer. This is not compatible with the mutuality principle. It is said that insurers are reluctant to enter into insurance lines with potentially catastrophic losses because of their limited reserves to face these risks. This argument does not take into account reinsurance chains that would spread risks worldwide. After all, even the worst scenario of a "Big One" earthquake in downtown San Fransisco would cost 100 10^9 dollars, which means a $400 loss per US citizen if the risk is perfectly diversified in the country, not mentioning international diversification. A more convincing argument would be that the reinsurance industry faces transaction costs at any element of the chain. This would strongly limit the efficiency of reinsurance and the possibility to spread risk on insurance markets. The question is then why insurance companies with a well-diversified ownership

structure are unable to raise enough reserves on financial markets to underwrite such risks? This problem is examined in section 9.2.

4. ADVERSE SELECTION

Since the seminal paper by Rothschild and Stiglitz (1976), it is recognized that the fact that insurers face an heterogeneous population of consumers is a source of inefficiency on insurance markets. The classical model presented above allows for an heterogeneous population as long as the characteristics of the risk borne by each agent is common knowledge. For example, the fact that women are safer drivers than men is compatible with full insurance of every driver at the competitive equilibrium with a risk-neutral insurance industry. The premium rate for every category of risk will be fair, thereby inducing each individual to purchase full insurance at the optimum.

A problem arises when the population is heterogeneous, but the observable characteristic of the agents are not perfectly correlated to the intensity of their risk. The adverse selection problem originates from the observation that if insurance companies calculate the premium rate on the basis of the average probability distribution in the population, the less risky agents will purchase less insurance than riskier agents. In the extreme case, the low-risk agent will find the premium rate too large with respect to their actual probability of loss. They will prefer not to insure their risk. Insurers will anticipate this reaction, and they will increase the premium rate to break even only on the population of high-risk policyholders.[4] The presence of high-risk agents generates a negative externality to lower-risk agents who are unable to find an insurance premium at an acceptable premium rate. To illustrate, this is probably why the proportion of households that purchase life insurance is so small, despite the potential severity of the risk. People have private information about their health status that cannot be observed by insurance companies. Then, only those with the lowest life expectancy purchase life insurance.

The policy recommendation that is relevant to reduce adverse selection is to make public all relevant information about risks. For example, insurers should be allowed to know whether the potential policyholder has some severe illness. They should also be allowed to use genetic testing. Insurance companies should also be allowed

to pool their information. In France, genetic testing has been prohibited by the pool of insurance companies. Asking questions related to AIDS is prohibited by law, together with pooling information with other insurance companies or banks. Clearly, there are ethical reasons for that. Another standard argument is that if this type of information is public information, then high-risk individuals would face an insurability problem. We strongly disagree with this argument. Indeed, this is not because the premium rate is high that the risk is not insurable. As long as the premium rate corresponds to the intensity of the risk, there is room for insurance. Quite to the contrary, by prohibiting discrimination or public information, one artificially increases the premium rate of lower-risk agents, thereby introducing an insurability problem of the type described above for low risks.

There is an European syndrome for forcing the insurance sector to redistribute wealth among different categories of risk through the prohibition of discrimination. This is particularly obvious for risks related to human capital (unemployment, health, life). This is also true for natural disasters (uniform pricing in France), automobile, environmental risks, ... Our claim is that the regulator has dramatically underestimated the cost generated by adverse selection. The regulator should rather allow for more discriminatory pricing in the insurance sector, probably reallocating wealth by taxes.[5]

5. EX ANTE MORAL HAZARD

The population of risks can be heterogeneous not only because agents bear intrinsically different risks, but also because they do not invest the same amount of their energy, wealth, or time to risk prevention. In particular, it has long been recognized that individuals that are better covered by insurance invest less in risk prevention if the link between the premium rate and the size of these investments is weak. It will be the case if insurers are not in a position to observe the investment in risk prevention by the insured. In that case, the premium rate is not sensitive to the effort made by the policyholder to prevent losses. Obviously, contrary to the result of the classical model, there will be an inverse relationship between risk prevention and insurance coverage. The level of risk prevention will be inefficient. This is ex ante moral hazard. Anticipating this low degree of prevention and the higher frequency of losses that it entails, insurers will raise their premium rate. Full insurance

will not be optimal for agents. At the limit, no insurance can be an equilibrium.[6]

To illustrate, this is why it is not possible to insure against promotion at work, about failure at school or university, about the lack of demand for a new product, or about divorce. In some extends, this is also why it is hard to insure against unemployment, or against environmental and technological risks.

The policy recommendation to fight against ex ante moral hazard is the enforcement of norms for risk prevention. This is the case for environmental risks in which ships transporting chemical products have to satisfy several safety requirements that are imposed by regulatory agencies. Automobile driving norms are also standard, as speed limits, alcohol-free driving, ... Why these norms are mostly organized by a regulatory agency rather than by insurers is not completely clear. One reason is due to the combination of negative externalities and limited liability. If they are more than one principal supervising the implementation of norms, the information among the different principals should be pooled to save on monitoring costs. For example, auto insurers should be allowed to get the information about driver fines by the police. This is not allowed in France.

Another policy recommendation is to allow insurers to discriminate prices among different policyholders. Allowing for discrimination is a way to provide incentive to policyholders to invest in risk-reducing activities. In France again, insurers are not allowed to discriminate premium rate for natural risks. The consequences are by now obvious: many households built their house in areas that were secularly known to be flooded periodically. The absence of actuarial insurance pricing was supposed to be counterbalanced by the imposition of strict norms for where to build houses. But these norms have never been written...

6. EX POST MORAL HAZARD

Ex post moral hazard relates to the risk of fraudulent claims. We assumed in the classical model that the size of the loss was observable. There are many instances in which this is at best a crude approximation of the real world. Contracts can be made contingent only upon observable events. The problem here is to give the good incentives to the policyholder to report her actual loss.

The inability for insurers to verify claims is at the origin of why it is not possible to insure against loss of happiness, or against some forms of sufferings that cannot be measured by physicians. Weisberg and Derrig (1991) and Dionne and Gagné (2000) measure the intensity of fraud in automobile insurance.

There exist other types of risk for which outcomes can be observed by the insurer only at a relatively high auditing cost. Townsend (1979), Mookherjee and Png (1989), Picard (1996, 1998) and others analyzed the optimal risk-sharing scheme in this case. If there is no limit on the penalty that can be imposed to policyholders that do not declare the actual level of their loss, the first-best solution can be attained. Indeed, insurers should announce that they will audit claims with some probability p that is very low. If the insured made a fraudulent claim, a $+\infty$ penalty ("death penalty") is imposed to him. This is enough to give the good incentive not to fraud on the insurance contract, even if p is very small. In this case, the fact that there is costly claim verification is not detrimental to welfare, and the risk is insurable in full.

But there are several reasons to believe that an infinite penalty in case of a fraudulent claim is not a realistic assumption. There are ethical reasons why an infinite penalty is not acceptable by Society. Also, there is limited liability (see section 7 for more details). Finally, insurers and third parties may often observe the size of the loss only with an error when auditing. The risk of error could well induce the insurer to punish a policyholder who reported his loss correctly. Ex ante, it is then Pareto-efficient to limit the size of the penalty. In order to report her loss correctly, the insurer will have to audit claim at a high frequency. This entails additional costs on the insurance contract. If the auditing cost is high, or if the frequency of audit necessary to give the good incentive for the policyholder to reveal the truth is too high, consumers would be better off by not insuring the risk. Notice that another way to reduce the willingness to submit a fraudulent claim is to limit the indemnity. The maximal indemnity that is compatible with truth-telling is an increasing function of the penalty and of the probability of audit. Consumers would like to announce ex ante that they will not submit fraudulent claims ex post. That would allow insurers to save the audit cost, thereby reducing the equilibrium premium rate, but the announcement is not credible.

Is ex post moral hazard an important problem? It is often suggested that the cost of fraudulent claims may well amount up to 10% of premiums paid for some insurance lines as automobile

insurance or homeowner insurance. This estimation is just about paying unjustified indemnities to policyholders, not the auditing cost to fight against fraud. This percentage is comparable to the rate of transaction costs, whose effects on insurability has been previously examined.

The policy recommendation is clear from the discussion above: one should impose larger penalty to policyholders that have been convicted of a fraudulent claim. Several countries in Europe have been weak in this area, recognizing fraud as a "national sport" that should be forgiven. By doing so, the legal system imposes a probably large cost to Society in terms of a loss of insurability. This weakness has been particularly clear for insurance lines where the indemnity payer does not have the good incentives to be though on fraud. For example, one may question about whether European social security organizations are fighting fraudulent claim efficiently. This yields a general distrust to the system, which is detrimental to unemployed themselves. Also, successive governments in France publicly ordered insurance companies to be "generous" with their policyholders every time a natural disaster occurred. The same effect is also apparent about agricultural mutuals, funded by the taxpayers in France, to provide indemnities without audit. The capture of the regulator in charge of indemnifying victims generates an important loss of efficiency in the allocation of risks.

7. LIMITED LIABILITY

An individual can cause a damage to others, either in the course of his/her profession (medicine, surgery, house-building, ...) or because of other activities (e.g. driving a car). The same kind of external random effect occurs for firms. In most countries, the agent found liable to a damage to others must indemnify them accordingly. This is done to force decision makers to internalize all costs generated by their choice. But indemnification is possible up to the decision maker's financial capacity. Limited liability is a way to protect risk-takers against an excessive financial distress. But it has long been recognized that limited liability distorts the decision of the risk-taker in a way that is socially inefficient. The US Saving and Loans crisis is often explained by the fact that "zombie" S. and Ls adopted in the early eighties a very risky attitude in an attempt to "bet for resurrection" after some blows on their portfolio of (real

estate) assets. This is because limited liability gives the agent the equivalent of a free put option. Put it in simpler terms, under limited liability, an insolvent agent can only benefit from taking more risk, because he does not bear the burden of losses. Therefore, if he is risk-neutral, he will seek to maximize the expectation of a convex function of his wealth. As a result, he will systematically exhibit a risk-loving behavior, and adopt a very risky attitude. This is a kind of moral hazard problem. Risk aversion mitigates this result, but only for agents who are well capitalized, as shown by Koehl, Gollier and Rochet (1996).

The effect of limited liability of the policyholder on his demand for insurance is thus unambiguous: if he is risk-neutral, it is never optimal to cover a risk of loss, even in the most favorable case where the premium rate is fair. Insuring the risk would yield a sure reduction in wealth equaling the expected loss. Not insuring the risk would yield an expected reduction of wealth that is less than it, since the agent bears only part of the risk of loss. Another way of looking at this problem is that the insurance contract create a "deep pocket" where victims can find compensation for their losses. This kind of problem is particularly crucial when examining the demand of insurance by firms for catastrophic environmental risks. Limited liability on the part of the insurance also reduces the demand of insurance, since it makes the indemnity dependent to its solvency.

Limited liability thus raises several important questions. How to organize compensation for those who bear the negative externalities? How to build an incentive-compatible mechanism that increases loss prevention by decision makers with limited liability? How to solve the market failure of liability insurance markets? How to force firms not to under-capitalize their subsidiaries which are in charge of managing the riskiest part of the business? Two routes have been used. The first one is compulsory insurance. This solves the misallocation of risk in the economy and the organization of a system to compensate the victims. But, most of the time, compulsory insurance has been funded by a flat, non-discriminatory, non-incentive-compatible insurance tariff. The policyholder's investment in loss prevention is not observed by the fund, either because it is difficult to get information on it, or because the fund did not get the good incentive to organize an incentive-compatible system.

The second route has been to organize "deep pocket" for decision makers. It means for example that the hospital who employs

an uninsured physician will be made liable in case of the physician's insolvency. Under the US CERCLA, when a bank has been relatively closely involved in the monitoring of a firm's activities, it may be considered by the courts as liable for cleaning up the environmental damages generated by the insolvent firm. The objective of this strategy is to force risk-takers to internalize the full cost of potential losses: the hospital will reduce the income of the careless physician, and banks will increase the loan rate of riskier firms. If there is no asymmetric information between the principal (the hospital, the bank) and the agent (the physician, the firm), the agent will select the socially efficient level of care and insurance. There would be no more insurability problem. But, as observed by Boyer and Laffont (1995), there is no reason to believe that the principal can monitor the agent at no cost. The CERCLA legislation, for example, introduces more asymmetric information on credit markets. Consequently, there will be more credit rationing, the cost of capital will be larger, and the structure of banking contracts for firms will be affected. Is insurability worth this cost?

8. AMBIGUITY

There are many instances in which the random variable describing the risk has no objective probability distribution. This can be due to the absence of historical data. Or because of our imperfect scientific knowledge, for those who believe in a deterministic world. To illustrate, who knows the actual probability distribution of a major leak in some specific type of nuclear plan, the probability of transmission to the human being of the so-called "mad cow" disease, the probability of failure of the new European satellite launcher Ariane V, or the probability of accident of a new inexperienced driver? This can also be due to a volatile environment, as is the case for future liability rules of the environmental policy. The ambiguity about the probability distribution raises several questions. How to calculate a fair insurance premium? How to evaluate the benefits of an insurance contract for the insured? What would be an efficient allocation of risks in the economy?

The defenders of the orthodox theory claim that ambiguity is no problem. Namely, the Subjective Expected Utility model states that, under some simple axioms on the behavior of the agent under uncertainty, he will use some subjective probability distribution to evaluate his welfare. For example, the inexperienced driver will use

some subjective probability of accident, say 15%, to determine his optimal deductible and his optimal investment in prevention. The potential problem, however, comes from the fact that the insurer may have different prior beliefs, say 20%, about the probability of accident of this specific type of inexperienced driver. If the two parties are "agree to disagree" on their respective prior beliefs, the model simplifies to the analysis of the effect of the insured's optimism on his insurance demand. In this particular example, the policyholder will observe the excessive probability of accident used by the insurer as an additional loading factor to the premium calculation. Consequently, the agent's demand for insurance will be smaller than if the beliefs were the same. At the limit, the agent may prefer not to insure the risk. Ambiguity would be a source of uninsurability. On the contrary, if the a priori probability of accident is larger when estimated by the policyholder than for the insurance company, the demand for insurance will be increased. Since there is no specific reason why to belief that consumers are intrinsically more optimistic than insurance companies, the argument has still to be refined to provide a credible explanation for uninsurability.

Notice that supply and demand can convey information about the size of the risk when the two parties have some private information on it. For example, a large premium rate can provide an information to the consumer that his risk is in fact larger than he believes. However, this can be a strategical behavior by the insurer to influence the beliefs of its policyholders. This could provide an explanation of why insurers look like being more pessimistic than its policyholders, yielding uninsurability as a temporary equilibrium.

There is another explanation of why ambiguity may lead to an insurability problem. Ellsberg (1961) noticed that a large population of agents violates the prediction of the Subjective Expected Utility Theory. Namely, they seem to have a bias in favor to decisions that eliminate the possibility of facing ambiguous distributions. For example, the inexperienced driver can eliminate using subjective probabilities to compute welfare by purchasing full insurance. This concept is called "ambiguity aversion". It drastically differs from the concept of risk aversion that is related to a preference for sure wealth. If only the policyholder is ambiguity-averse, this is a factor for an increase in the equilibrium coverage of insurance. If, on the contrary, only the insurer is ambiguity-averse, this is a factor of uninsurability. The concept of ambiguity aversion has received a precise theoretical content by the works of Gilboa and Schmeidler (1989).

9. DYNAMIC ASPECTS OF INSURABILITY

9.1 Realized Risk

In many circumstances, risks borne by agents are not independent through time. For example, my health status tomorrow is affected by my health status today. Thus, health insurance will be more expensive for people with a poor current health. The extreme form of this is a "realized risk" in which the evolution of the random variable in the future became deterministic, given the current situation. Obviously, there exists no mutually advantageous risk transfer in this case. In short, one cannot insure a risk ex-post.

External information on the scale of a risk can yield the same effect. Genetic testing will soon inform us about the evolution of our health. If this information is made available to the market, the scope of insurance will be much reduced. Hirshleifer (1971) already noticed that more information can have a negative value for Society. Early information on risks will make these risks uninsurable. This so-called "Hirshleifer effect" may be escaped if insurance could be organized prior to the revelation of the information. Whether the outcome of genetic tests will be insurable in the future is central for the future of life and health insurance systems. In France, the prohibition of genetic information revelation to insurers is considered by the legislator. This would for sure have a dramatic consequence for insurance markets, because it would introduce an incredible amount of adverse selection in them. Only those with a bad genetic profile will be willing to purchase insurance, raising the break-even premium rate, thereby excluding good risks from the market. The same kind of problem will occur if one improves our ability to forecast future earthquakes, or other natural disasters.

This phenomenon indicates the importance for insurance markets to establish long-term relationships between the buyer and the seller of a risk. Health insurance would have a much smaller value if, at any time, one party could renege the contract. This links this discussion to the assumption made in the classical model that there exist insurance markets for future risks. The problem here is our inability to insure future generations against future risks. There are simply not present on markets to purchase insurance contracts. This is a particularly important problem for environmental and technological risks.

9.2 Precautionary Reserves and Time Diversification

Risks can be transferred between individuals, but it can also be transferred through time via the credit markets. Individuals can forearm themselves in the face of uncertainty by saving. Under some technical conditions developed in Gollier and Kimball (1996), precautionary saving and insurance are substitutes, i.e. the insurability of the future risk reduces the willingness to save. As shown by Yaari (1976), an agent with an infinite time horizon and with risks that are independent through time would "time-diversify" his risks by an efficient borrowing-lending strategy that perfectly smooths his consumption through time. No insurance would be necessary in this case. Risks would be uninsurable by lack of insurance demand. But households have finite time-horizon. They face risks that are dependent from one period to another. These two effects limit the efficiency of time-diversification, and it provides room for insurance.

The "time-diversification" strategy is also made difficult to implement because credit markets are not perfect. In particular, agents face a liquidity constraint, i.e. they cannot borrow a large amount of money in case of an "early hit" of damages. Deaton (1991) shows that the existence of a liquidity constraint may have a very large effect on the variability of the optimal consumption plan when there is no insurance available. The liquidity constraint that consumers face on credit markets is thus an important determinant of the demand for insurance.

Gollier (1994) examines the optimal dynamic strategy of a risk-averse agent bearing an insurable risk to determine whether precautionary saving is superior to insurance in the long run. In his model, the risk of loss follows a Poisson process. In the short run, the optimal strategy is to transfer most of the risk to the insurer, because the agent has no enough financial reserve to be used in case of an "early hit" of damages. If he is sufficiently lucky, and if his consumption rate is low enough, he will be able to accumulate more reserves that will allow him to retain a larger proportion of the risk in the future. This is desirable, because reserves generate a positive expected return, and because insurance is costly. Gollier (1994) characterizes the best compromise between two conflicting objectives in the short run: protecting the agent against large losses and raising reserves to reduce the cost of the risk in the future by reducing insurance coverage. These objective conflict because the first is attained through spending enough money for insurance and the second saves on insurance costs today. Gollier shows that the

demand for insurance vanishes in the long run if transaction costs on insurance markets exceed a critical positive value.

This model can be reinterpreted for large firms funding an insurance captive to organize risk retention, together as for insurance companies determining their strategies of capital accumulation and reinsurance. A starting insurance company has a low capacity to retain risks. It is thus forced to reinsure a large part of their business. If it is not caught by an "early hit" of catastrophic indemnities, its capacity to retain risk will grow. This will increase the capacity of the market.

The ability of insurance companies to transfer wealth through time is thus central for organizing time diversification of catastrophic risks. But the modern theory of corporate finance indicates that managers in firms with a large financial reserve will be less efficient than managers in less capitalized firms where their job is at stake. Managerial inefficiencies open the door to raiders who could use the cash reserve of the insurance company for his own purpose. The bottom line is that it can be hard for insurance companies to accumulate financial reserves. This has an adverse effect on the capacity of the insurance market.

10. CONCLUSION

Insurance plays a key role in the functioning of our modern economies. Insurance contracts transfer individual risks to financial markets through shareholders of insurance companies. It allows for a reduction of risks borne by Society through diversification. It also allows for transferring risks to agents that have a comparative advantage to bear risks, i.e. more risk-tolerant agents. The added value for the economy is considerable: it directly increases the welfare of the risk-averse policyholders, but it also induce risk-averse entrepreneurs to invest more in risky activities, thereby increasing growth and employment.

This view on the functioning of our economies is idealistic. There are several reasons why a large proportion of uncertain events cannot be insured efficiently by competitive insurance markets. Transaction costs is an obvious reason for this. The fact that losses can be very large is not, in itself, a convincing argument explaining the limits of insurability. Indeed, the larger are potential losses, the larger is the risk premium that the consumer is ready to

pay to get rid of the risk. Similarly, the expected utility theory cannot explain why it seems to be relatively more difficult to insure low probability events.

Adverse selection and moral hazard are now two well-established explanations of markets failure on insurance markets. To deal with adverse selection, policy-makers should help insurance markets by making all information available to the parties, and by reducing ex ante wealth inequalities by income redistribution. Ex ante moral hazard problems can be dealt with by organizing norms for risk prevention and by allowing insurers to offer special rates for policyholders investing in prevention. Ex post moral hazard is weakened by organizing an efficient legal system to fight against fraud. Limited liability for the risk-taker is another explanation for why some risks are not covered by an insurance contract. The consequences of limited liability on risk prevention and insurance demand can be controlled by imposing a "deep pocket" rule for decision makers, but this policy can have some adverse effects.

The fact that insurers and consumers may perceive risks differently is another source of uninsurability if insurers are more pessimist than consumers, or if insurers are more ambiguity-averse than consumers. The fact that many have a dynamic nature can explain uninsurability. One should help markets to offer opportunities to build long-term relationships between policyholders and insurers. This is how consumers will be able to cover risks that may have a long-term effect on their welfare.

☐ References

Aase, K. K., (1993), "Equilibrium in a Reinsurance Syndicate: Existence, Uniqueness and Characterization," *Astin Bulletin* 23, 185-211.

Arrow, K.J., (1953), *Le rôle des valeurs boursières pour la répartition la meilleure des risques*, Edition du CNRS, Paris.

Arrow, K.J., (1965), *Aspects of the Theory of Risk Bearing*, Yrjo Jahnsson Lectures, Helsinki. Reprinted in *Essays in the Theory of Risk Bearing* (1971), Chicago: Markham Publishing Co.

Berliner, B., (1982), *Limits of Insurability of Risks*, Englewood Cliffs.

Borch, K., (1962), "Equilibrium in a Reinsurance Market," *Econometrica* 30, 424-444.

Boyer, M. and J.-J. Laffont, (1995), *Environmental Risks and Bank Liability*, mimeo, Université de Montéal.

Deaton, A., (1991), "Saving and Liquidity Constraints," *Econometrica* 59, 1221-1248.

Dionne, G., (2000), "The Empirical Measure of Information Problems with Emphasis on Insurance Fraud," in *Handbook of Insurance*, G. Dionne (Ed.), Kluwer Academic Publishers, 395-420.

Dionne, G., and R. Gagné, (2000), *Replacement Cost Endorsement and Opportunistic Fraud in Automobolie Insurance*, mimeo, HEC Montréal.

Eeckhoudt, L. and C. Gollier, (1995), *Risk: Evaluation, Management and Sharing*, Harvester Wheatsheaf, Hertfordshire (G.-B.).

Eeckhoudt, L. and C. Gollier, (1999), "The Insurance of Low Probability Events," *Journal of Risk and Insurance* 66, 17-28.

Gollier, C., (1992), "Economic Theory of Risk Exchanges: A Review," in *Contributions to Insurance Economics*, G. Dionne (Ed.), Kluwer Academic Press, 3-23.

Gollier, C., (1994), "Insurance and Precautionary Saving in a Continuous-Time Model," *Journal of Risk and Insurance* 61, 78-95.

Gollier, C., P.-F. Koehl and J.-C. Rochet, (1996), Risk-Taking Behaviour with Limited Liability and Risk Aversion, mimeo, University of Toulouse.

Gollier, C., and M.S. Kimball, (1996), Toward a Systematic Approach to the Economic Effects of Uncertainty : Characterizing Utility Functions, mimeo, University of Michigan.

Gilboa, I. and D. Schmeidler, (1989), "Maximin Expected Utility with Non-Unique Prior," Journal of Mathematical Economics 18, 141, 153.

Hirshleifer, J., (1971), "The Private and Social Value of Information and the Reward of Inventive Activity," American Economic Review 61, 561-574.

Holmstrom, B., (1979), "Moral Hazard and Observability," Bell Journal of Economics 10, 74-91.

Kahneman, D. and A. Tversky, (1979), "Prospect Theory: An Analysis of Decisions Under Risk," Econometrica 47, 313-237.

Kunreuther, H., (1996), "Mitigating Losses and Providing Protection Against Catastrophic Risks: The Role of Insurance and Other Policy Instruments," Geneva Papers on Risk and Insurance Theory, forthcoming.

Mossin, J., (1968), "Aspects of Rational Insurance Purchasing," Journal of Political Economy 76, 533-568.

Mookherjee, D. and I. P'ng, (1989), "Optimal Auditing, Insurance, and Redistribution," Quarterly Journal of Economics 103, 399-415.

Picard, P., (1996), "Auditing Claims in Insurance Markets with Fraud: The Credibility Issue," Journal of Public Economics 63, 27-56.

Picard, P., (2000), "Economic Analysis of Insurance Fraud," in Handbook of Insurance, G. Dionne (Ed.), Kluwer Academic Publishers, 315-362.

Raviv, A., (1979), "The Design of an Optimal Insurance Policy," American Economic Review 69, 84-96.

Rochet, J.-C., (1991), "Incentives, Redistribution, and Social Insurance," Geneva Papers on Risk and Insurance Theory 16, 143-165.

Rothschild, M. and J. Stiglitz, (1976), "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," Quarterly Journal of Economics 80, 629-649.

Segal, U. and A. Spivak, (1990), "First Order Versus Second Order Risk Aversion," Journal of Economic Theory 51, 111-125.

Townsend, R., (1979), "Optimal Contracts and Competitive Markets with Costly State Verification," Journal of Economic Theory 21, 1-29.

Weisberg, H.I., and R.A. Derrig, (1991), "Fraud and Automobile Insurance: A Report on Bodily Injury Liability Claims in Massachussetts," Journal of Insurance Regulation 9, 497-541.

Yaari, M.E., (1976), "A Law of Large Numbers in the Theory of Consumer's Choice under Uncertainty," Journal of Economic Theory 12, 202-217.

☐ Notes

1. See Borch (1962), Arrow (1953), Mossin (1968), Raviv (1978) and Gollier (1992).

2. See Eeckhoudt and Gollier (1995) for a synthesis on Pareto-efficient and competitive risk-sharings.

3. This is specific to the Expected Utility model and to other models that satisfy second-degree risk aversion, a concept defined by Segal and Spivak (1990).

4. The literature on adverse selection is devoted to characterizing an equilibrium. Insurers will use the fact that low-risk ,3agents and high-risk agents behave differently in the face of a large set of insurance contracts. In particular, low-risk agents could credibly signal their type by selecting a contract with a large deductible, something that high-risk agents dislike.

5. For another view on this problem, see Rochet (1991).

6. Holmstrom (1979) characterized the equilibrium insurance contract with ex-ante moral hazard.