The determinants of the insurance demand by firms

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Abstract

In this paper, we provide a survey of the literature on why risks may be costly for firms, but also on why firms may find difficulty to insure them. A wide variety of arguments are provided, at the intersection of the economic theory of insurance, corporate finance, and decision theory.

1 Introduction

The possibility to share risk is a cornerstone of our modern economies. Because risk-sharing allows for risk-washing through diversification, it is useful for risk-averse consumers. It is also essential for entrepreneurship. Without risk transfers, who could have borne alone the risk to build skyscrapers and airplanes, to invest in R&D, or to drive a car? Historians have well documented the role of private risk sharing devices in the development of trade in the middle ages, in particular in the case of sea transport. The successes of the Netherlands in the seventeenth century and of the England in the eighteenth century are strongly correlated with the emergence of financial markets and insurance companies in those countries. The prohibition of insurance companies in France during the same period is one of the explanations for the late starting of the industrial revolution there.[1] The importance of risk-sharing has recently been restated when insurance markets have been on the verge of collapsing after the events of September 11.

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 individual risks are insured. 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, they are "winners" and "losers". This is the expression of an inefficient risk sharing ex ante.

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. Small business risks are usually not insured, and new entrepreneurs are left alone with the riskiness of their projects. As a consequence, many of their socially valuable projects are not implemented. It yields a reduction in investment, employment and growth. Moreover, the

[1] See Bernstein (1997) and Baskin and Mirandi (1997) for a short description.

failure of some of the implemented projects lead to dramatic individual situations for their residual claimants. Given risk aversion, it has a sizeable adverse effect on ex ante welfare.

The absence of insurance covering various risks borne by firms does not necessarily yield an inefficient allocation of risk in the economy. In particular, shareholding companies may find it optimal to retain most of their business risks in their balance sheet. To simplify the argument, consider a risk that is independent of the macro risk in the economy. Then, a shareholder with a well diversified portfolio would bear no additional risk by requiring that this risk be retained by the firm. On the contrary, insuring the risk would impose additional costs for the firm, because insurance usually yields a positive loading. This would reduce the profitability of the firm, with no benefit for shareholders in terms of risk reduction of their portfolios. Thus, the puzzle for shareholding companies is quite opposite to the one that I described above, and can be coined by the following question: Why do corporations purchase costly insurance?

In this paper, we try to cover these two aspects of the question by discussing the determinants of the demand of insurance by firms. On one side, we will examine the limit of insurability of some of the risks that should be – but are not – covered by an insurance contract. On the other side, we will provide arguments for why do some shareholding companies insure some risks in spite of the ability of shareholders to wash them out more efficiently through diversification in their portfolios.

We will first review the standard theory of risk-sharing. We will then review the determinants of the demand for insurance by considering two different categories. In section 3, we consider the determinants and their limit that can be applied to any economic agents, not only firms. In section 4, we focus on the additional elements that are specific to firms.

2 The economics of diversifiable risk sharing

The standard economic model of risk exchanges has been introduced by Arrow (1953), Borch (1962) and Wilson (1968)). Suppose that there are S possible states of nature indexed by $s = 1, ...S$. There are n agents in the economy. Agent i has a state-dependent wealth ω_s^i in state s. To each possible state of nature s, there exists an insurance market where agents can

trade a standardized contract that would entitle its owner (the policyholder) to get one monetary unit (the indemnity) from its counterpart (the insurer) if and only if state s occurs. Let π_s denote the price (the premium) of this contract. We assume that economic agents trade in order to maximize the expected utility of their final wealth. For example, agent i solves the following maximization program:

$$\max_{d_1,...,d_S} \sum_{s=1}^{S} p_s u_i(\omega_s^i + d_s) \qquad s.t. \qquad \sum_{s=1}^{S} \pi_s d_s = 0,$$

where p_s is the probability of state s, $u_i(.)$ is the increasing and concave utility function of agent i, and d_s is his demand for the insurance contract specific to state s. The budget constraint just states that agent i must finance his purchase of insurance coverage in some states by selling insurance coverage associated to other states. Observe that we assume that state probabilities are common knowledge, that the realized state is observable by all parties, and that there is no transaction costs. The above program has a solution $(d_1^i, ..., d_S^i)$. When solved for all agents in the economy, this generates an aggregate demand for the insurance contract associated to state s equaling $D_s = \sum_i d_s^i$ that depends on the price vector $(\pi_1, ..., \pi_S)$. A market-clearing condition is thus that $D_s = 0$. Requiring that this condition holds in all insurance markets $s = 1, ..., S$ yields S conditions that allows to determine the competitive price vector of insurance contracts. This in turn determine the exchanges of risk at the competitive equilibrium. As is well-known, this competitive allocation of risk is Pareto-efficient in the sense that there is no other feasible allocation of risks that raises the expected utility of an agent without reducing the expected utility of any other agents.

The competitive allocation of risk has many insightful properties. In particular, 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. Let $z_s = \sum_i \omega_s^i / n$ denote the mean wealth in the economy in state s. Individual risks are diversifiable if $z_s = z$ for all s, that is, if the mean wealth in the economy is risk free. In that situation, it is easy to show that $c_s^i = \omega_s^i + d_s^i$ will be independent of s for all i, which means that agents will get full insurance in that economy. It implies more generally that individual consumption levels c_s^i depends upon the state only through the mean wealth in that state: $c_s^i = c^i(z_s)$

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 individual risks are insured by insurance companies which transfer the aggregate risk to financial markets. More specifically, the competitive equilibrium must be such that

$$\frac{dc^i(z)}{dz} = \frac{T^i(c^i(z))}{\sum_{j=1}^n T^j(c^j(z))},$$

where $T^i(c) = -u_i'(c)/u_i''(c)$ measures the degree of absolute risk tolerance of agent i. This formula tells us that the share of the systematic risk borne by agent i is proportional to his risk tolerance. Gollier (2001) gives a more detailed description of the properties of efficient allocations of risk.

We can derive the following predictions from this model. First, economic agents should be able to transfer 100% of their diversifiable risks to the economy. This can be done either through insurance markets with actuarial prices, or through other risk-sharing schemes, such as solidarity mechanism, or as some alternative financial arrangements (equity financing, cost-plus procurement contracts,...). Second, they should retain a fraction of risks that are correlated with the aggregate risk of the economy (such as natural catastrophes or various risks related to the business cycle). Third, shareholding companies should be indifferent between transferring risk to their shareholders or purchasing insurance contracts at competitive prices. The predictions of the classical insurance model are obviously contradicted by casual observations. The remainder of this paper is devoted to solving this puzzle.

3 General explanations for uninsurability

In this section, we review the explanations for uninsurability that can be applied to any risk, not only those borne by firms.

3.1 Transaction costs

Contrary to what we assumed above, providing insurance is a costly activity. The insurer must cover administrative costs linked to the monitoring of individual insurance policies. It must control for ex ante and ex post moral

hazard. That entails in particular expensive audits of large claims. In addition, insurers usually face the problem of adverse selection. They must invest in costly efforts to screen their customers. It is commonly suggested that all this yields a 30% loading factor for insurance pricing. In other words, insurers must have a loss-to-premium ratio that does not exceed 0.7 in order to break even on average.

When insurance is costly, the choice of the level of coverage is not a simple matter. Arrow (1963) and Mossin (1968) were the first to examine this question in a simple static model. Mossin (1968) showed that it is never optimal to purchase full insurance when insurance policies are not actuarially priced. Consider an agent who purchased a full insurance contract and who contemplates the possibility to switch to a policy yielding a small retention. The benefit of switching comes from the reduction of the deadweight insurance cost. The cost of switching comes from the risk premium linked to the retained risk. As seen in Figure 1, the risk premium increases from zero as the square of the size of the retained risk. Thus, the marginal cost of retaining a small share of the insurable risk is zero. In consequence, given the positive marginal benefit of risk retention, no expected-utility-maximizer consumer should purchase full insurance.

Arrow (1963), showed that the optimal form of risk retention is given by a straight deductible. The optimality of a straight deductible is the expression of the relevance of insurance for large risks. Small risks, i.e. risks whose largest potential loss is less than the optimal deductible should not be insured. Given the cost of insurance, risk-averse entrepreneurs should find it optimal to self-insure the risk of a one-day business interruption, but they should try to insure their main warehouse against fire. Drèze (1981) estimated the optimal level of deductible in insurance. It is a decreasing function of risk aversion. If we accept a range $[1, 4]$ for relative risk aversion, Drèze concluded that the optimal level of deductible should be somewhere between 6% and 23% of the wealth of the policyholder.

3.2 Adverse selection

In the classical model, it is assumed that all agents share the same information about the likelihood of the various states. This 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 some firms have a

smaller rate of accidents is compatible with full disability insurance for all firms at the competitive equilibrium with a risk-neutral insurance industry. The premium rate for every category of risk will be fair, thereby inducing each firm to purchase full employer disability insurance at the optimum.

A problem arises when the population of risks is heterogeneous, but the observable characteristics of the agents are not perfectly correlated to the intensity of their risk. The adverse selection problem initially pointed out by Rothschild and Stiglitz (1986) 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. 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.

There is no doubt that many business risks are firm-specific, and are thus very heterogeneous. Insurers can gather information to reduce the asymmetry of the information. They can use databases to infer the historic frequency and intensity of losses, or they can send auditors to evaluate the quality of safety procedures. But it is likely that this will not completely eliminate the uncertainty about how to categorize firms in different risk classes. This yields the adverse selection problem. Low risk firms will then prefer to self-insure, which is inefficient.

The policy recommendation that is relevant to reduce adverse selection is to make public all relevant information about corporate risks. Moreover, insurance companies should be allowed to discriminate their customers according to their perceived risks. Limiting their ability to discriminate would generate an adverse selection problem even in the absence of any asymmetric information. There is a 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, disability). This is also true for natural disasters (uniform pricing in France), automobile, environmental risks,.... Our claim is that the regulator has underestimated the cost generated by the adverse selection problem that this policy induces.

3.3 Ex ante moral hazard

In the previous section, we assumed that the riskiness of a firm is completely exogenous. In fact, 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. Again, this does not raise any specific insurability problem in the absence of any asymmetric information problem. Suppose indeed that insurers can observe the firms' preventive efforts. The more virtuous firms will be safer, and insurers will give them more favorable tariffs due to the competitive pressure. These insurance bonuses will provide the good incentive for firms to invest in prevention, and all firms will fully hedge their insurable risks. There is no insurability problem in that case.

Suppose alternatively that insurers cannot observe the investment in risk prevention by the insuree. In that case, the premium rate is not sensitive to the effort made by the policyholder to prevent losses. Obviously, the existence of an insurance contract reduces the firms' incentive to investment in prevention. This is so-called ex ante moral hazard. The level of risk prevention will be inefficient at equilibrium. Anticipating this low degree of prevention and the higher frequency of losses that it entails, insurers will raise their premium rate, as shown for example by Shavell (1979) and Holmstrom (1979). Full insurance will not be optimal for agents. At the limit, no insurance can be an equilibrium. The ex-ante moral hazard problem is probably the most plausible explanation for why most risks associated to a firm's core business are not insurable. The uncertainty about future profits cannot be insured because that would reduce too much the firm's incentive to maximize these profits.

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. Why are these norms mostly organized by regulatory agencies 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.

Another policy recommendation is again 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 consequence are by now obvious: too many firms built their warehouse in areas that were secularly known to be flooded periodically.

3.4 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 usually not possible to insure against the loss of easily movable and tradable assets. It is also well known that warehouses are more likely to burn during downturns of the economic activity, when the stored products are more difficult to sell. 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) 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. If the insuree made a fraudulent claim, a $+\infty$ penalty ("death penalty") is imposed to him. This is enough to give him 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. 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. Insurees 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 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.

3.5 Implicit risk-sharing versus insurance

A substitute for market insurance is to organize an implicit or explicit system of solidarity for the unlucky economic agents through an indemnity financed by the lucky ones. Social security is the most obvious example. The decision of the US government to compensate the relatives of the victims of September 11 and the shareholders of airline companies is another example. France is the prefect example of a country that established an implicit system of solidarity for unlucky citizens. Farmers and truck drivers for example can rely on the state to get compensations for adverse shocks to their profits. Victims of floods may expect to get indemnities that depend upon the power of their local representatives at the Parliament.

The solidarity system yields problems that are similar to those of the market insurance: adverse selection, moral hazard and fraud. Moreover, if the system is implicit, it generates some uncertainty about the level of the indemnity, because of the political nature of the intervention. But the most important difficulty is related to the non-stability of the coexistence of the solidarity system and the insurance system. If some agents believe that the state will compensate them for their damages, they will prefer not to insure the risk. Ex-post, the massive absence of insurance coverage forces the state to intervene. This is a case of self-fulfilling prophecy. One can mitigate this problem by asking the state to specify explicitly the conditions and the limits of national solidarity. However, such a commitment may be difficult. Ex-post, the social pressure for the public indemnification of the uninsured victims of a much publicized catastrophe will be strong. Solidarity kills market insurance. This problem can also be mitigated by offering public indemnities that are not contingent to the existence of an insurance contract covering the victim's loss.

3.6 Ambiguity

The possibility to transfer a risk to 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 basis of 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 may be applied. It means that the maximum potential loss may not be infinite, or very large. Similarly, the legal environment must be stable, or predictable. Finally, an objective distribution function should be subject to quantification.

This definition is not entirely satisfactory. The actuarial view on the limits of insurability appears to be too narrow. After all, the Lloyd's agreed to underwrite the risk of the capture of the monster of Loch Ness, and more standard insurance companies cover the risk of failure of new rocket launchers in spite of the absence of any relevant data on which an insurance tariff could be based. There are indeed 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 nature. To illustrate, who knows the actual probability of, for example,

- a major leak in some specific type of nuclear plans,
- an epidemy of avian flu next year, killing more than 100 000 Europeans,
- a large terrorist attack on the Italian territory next year,
- or the average temperature on earth to increase by more than 4 degree Celsius in the next century?

Ambiguous probabilities can also be due to a volatile environment, as is the case for future liability rules of environmental policies.

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 insuree? What would be an efficient allocation of risks in the economy? To keep it simple, suppose that there are two possible states of nature, a loss state and a no-loss state. The probability p of the loss state is unknown. Using all available information gives us an interval of confidence $[p_{\min}, p_{\max}]$, with a mean $\overline{p}$. Following the terminology of insurers, we are in a situation where there is no credible actuarial estimates of the risk, which "implies" that the risk cannot be priced, and that the risk is not insurable.[2] Let us try to understand this explanation of the limits

[2]The ambiguous probability cannot explain alone the uninsurability problem. Borch (1989) reports the Lloyd's insuring the risk of discovering the monster of Loch Ness.

of insurability. Keynes (1921) distinguished between probabilities and the weight of evidence. Probabilities represent the balance of evidence in favor of a particular event, whereas the weight of evidence represents the quantity of evidence supporting that balance. He then raised the following question: "If two probabilities are equal in degree, ought we, in choosing our course of action, to prefer that one which is based on a greater body of knowledge?"

The defenders of the orthodox theory claim that ambiguity is no problem. Following Savage (1954), people should behave as if there would be no uncertainty on probabilities. More precisely, they should use $\overline{p}$, i.e. the best probability estimate, to compute their expected utility. Ambiguity on probabilities should not play any role neither on welfare nor on behavior. In particular, it should not affect the demand and supply of insurance. Whereas this theory has a strong normative contain, it cannot explain various observations. Ellsberg (1961) showed in a well-known experiment that some people do not behave as Savagian agents. They don't behave in the same way in the face of two uncertain environments with the same probabilities, but with different weights of evidence. More precisely, they are ready to pay more to get rid of a more ambiguous risk. In the Keynes-Ellsberg's "two-color" problem, there are two urns each containing red and black balls. Urn 1 contains 50 red balls and 50 black balls, whereas urn 2 contains 100 red and black balls in an unknown proportion. A ball is drawn at random from an urn and one receives 100 euros or nothing depending on the color of the ball. The fact that people are indifferent to bet on red or black if urn 2 is used indicates that their subjective probability for each color is 0.5, as in urn 1. If they would be SEU maximizers, they should thus be indifferent to using urn 1 or urn 2 for gambling. However, most people prefer to gamble with the unambiguous urn 1, where the "weight of evidence" is larger.

The concept of ambiguity aversion has received a precise theoretical content by the works of Gilboa and Schmeidler (1989). Ambiguity aversion means that economic agents do use some probability p smaller than $\overline{p}$ to measure their welfare in the face of uncertainty. Pessimism is another word for ambiguity aversion. People may have different degrees of ambiguity aversion, as they may have different degrees of risk aversion. Notice that if both the policyholder and the insurer have the same degree of ambiguity aversion, they should use the same p to compute expected utility on one side, and the actuarial value of the policy on the other side. This should not introduce any specific insurability problem. The ambiguity raises the premium

required by the insurer to accept to cover the risk, but it also raises the policyholder's willingness to pay for insurance. An insurability problem may occur only if insurers are systematically more ambiguity-averse than consumers. Kunreuther, Hogarth and Meszaros (1993) conducted a series of studies to determine the degree of ambiguity aversion of insurers. They showed that many of them may exhibit quite a large degree of such an aversion.[3] For which reasons this is the case remains an open question. This could for example come from an incentive problem. Underwriters are usually much more penalized when it happens ex-post that they "underestimated" the risk of loss than when they "overestimated" it. Underestimation leads to the much visible problem for the company to face a loss ratio much larger than unity (asbestos in the US, transfused blood scandal in France,...). Overestimation yields unearned potential profits that are usually not even mentioned by the principal. Thus, underwriters would not be genetically more ambiguity-averse. Rather, they react to biased incentives. Solving this uninsurability problem requires a modification of incentive schemes for underwriters.

4 Insurability problems specific to entrepreneurial risks

In section 2, we explained that, when insurance transactions are costless, corporations should be indifferent to hedge their risks though insurance markets, or to transfer them unmanaged to their shareholders. Whether these risks are correlated to the macro risk or not is irrelevant for this conclusion à la Modigliani-Miller. This is because shareholders can undo what firms do in terms of risk-spreading by a symmetric reallocation of their portfolios. This is because they can diversify in their portfolios the non-systematic part of the corporation's insurable risks, whereas the shareholders of the insurance company would require exactly the same risk premium to accept to insure the systematic risk than the shareholders of the corporation. If we add transaction costs of insurance contracts into the picture, it becomes clear that shareholding companies would reduce their market value by insuring their

[3]Viscusi and Chesson (1999), using a sample of 266 business owners facing risks from climate change, show evidence of both ambiguity-seeking behavior and ambiguity-averse behavior. More precisely, people seem to exhibit fears effect of ambiguity for small probabilities of suffering a loss, and hope effects for large probabilities.

risks. In this section, we review the literature on corporate finance that explains why risk is costly to firms. This review provides additional characteristics of the insurance demand specifically for firms that complements what was presented in the previous section.

4.1 Taxes on corporate profits

Taxes on corporate earnings are usually not linear. In most countries, they are convex, in the sense that larger corporate earnings usually encounter larger marginal tax rates. As for individual income taxes, the first few hundreds euros of corporate earnings are untaxed. This may be due either to an explicit element in the tax code, or to the fact that some fixed expenditures, as capital depreciation, are tax deductible. Eeckhoudt, Gollier and Schlesinger (1997) examine the specific effect of the deductibility of past uninsured corporate loss on the corporation's risk attitude. The effect of all these deductiblities is to enlarge the range of corporate earnings with a zero marginal tax.

The convexity of the corporate tax scheme implies that the net-of-tax corporate earnings is a concave function of the corporate gross earnings. This implies that firms are averse to risks on gross earnings, even if these risks can be diversified through their shareholders' portfolios. The intuition is easy to understand. Suppose that the firm does not pay any tax if its earnings is below some threshold D, and that it pays a constant marginal tax t if earnings exceed D. We depicted the concave relationship between gross and net earnings of this firm in Figure 1. Suppose also that the firm expects a gross earning Y which is larger than D, if no accident occurs. Consider first an environment in which the firm faces a risk for which the maximum possible loss is smaller than $Y - D$. In this situation, the firm and the State share the risk proportionally, and are therefore neutral to it. That is, they are unanimously indifferent to purchase insurance at actuarial price. In particular, the firm gets full tax deductibility for the potential loss and for the insurance premium, so that the corporate tax is neutral to the insurance decision.

Suppose alternatively that the maximum loss exceeds $Y - D$. Here, the risk-sharing arrangement introduces a conflict of interest between the two risk bearers. From the point of view of the firm's owners, the insurance premium is fully tax deductible, but the potential losses are only partially

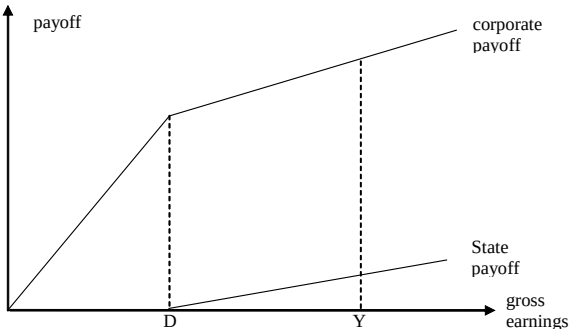

Figure 1: The conflict of interest between the firm's owner and the State when some fixed expenditures are tax deductible.

tax deductible. In that situation, it is clear that purchasing an actuarially fair insurance contract to cover potential losses reduce the expected tax payment to the State. Insurance is thus strictly preferred by the firm in this case. Of course, the interests of the State are strictly opposed to those of the firm in this case.

One interesting testable hypothesis derived from this analysis is that firms with a large reserve of losses to carry forward to future tax periods, i.e., a large tax shield, should be more willing to purchase insurance.

4.2 Agency costs between creditors and owners

At this stage, it is useful to go into more details in describing the "owner" of the firm. Usually, a corporation financed its past investments by borrowing money to creditors, and by sharing the property rights of the firm with various investors. These shareholders are the residual claimants on the value of the firms once creditors have been reimbursed. As long as the firm is not bankrupt, which normally occurs when the value of the firm V is less than the value of the debt D, the shareholders manage the firms. The right to manage the firm is transferred to the creditors in case of bankruptcy. This standard system of corporate governance has several well-known deficiencies.

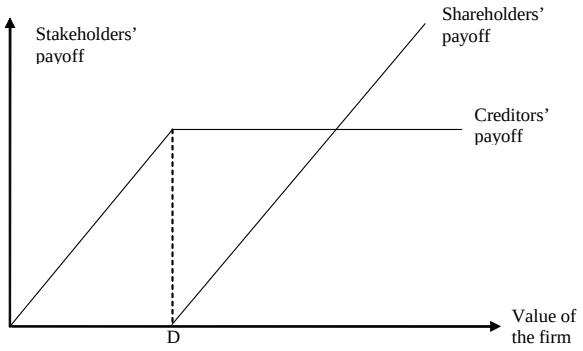

Figure 2: The conflict of interest between shareholders and creditors

In particular, there is an agency problem between creditors and shareholders when the value of the firm is relatively close to the value of its debt, as shown by Jensen and Meckling (1976). This agency problem originates from a conflict of interest between creditors and shareholders which is similar to the one described in the previous section between the firm's owner and the State. We draw in Figure 2 the payoffs of creditors and shareholders as a function of the market value of the firm. For a value of the firm less than the value of the debt, the firm is bankrupt, and the entire value goes to the creditors. Otherwise, the creditors get the reimbursement of the debt, and shareholders receive the value net of the debt.

Suppose first that the current market value of firm is much larger than value of the debt, so that the risk of bankruptcy is null. In that situation, the firm can finance its investment at a rate close to the risk free rate, and shareholders have the right incentive to manage the firm's risk. There is no agency problem in this situation. Suppose alternatively that the value of the firm is only marginally larger than the value of the debt. In that case, shareholders benefit from the upside risk of the firm's activity, but most of the downside risk is borne by creditors, because of the limited liability of shareholders. Limited liability gives the shareholders the equivalent of a free call option. Put it in simpler terms, under limited liability, the owners of an insolvent firm can only benefit from taking more risk, because they do not bear the burden of losses. Therefore, if they are risk-neutral, they will

seek to maximize the expectation of a convex function of his wealth. As a result, they 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 firms which are well capitalized, as shown by Gollier, Koehl and Rochet (1996).

It has long been recognized that limited liability distorts the shareholders' decision 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 late eighties a very risky attitude in an attempt to "bet for resurrection" after some blows on their portfolio of (real estate) assets. The more recent scandals of Enron and Parmalat also illustrate this point.

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 environmental risks. Limited liability on the part of the insurer also reduces the demand of insurance, since it makes the indemnity dependent to its solvency.

In the above analysis, we took the value of the debt as completely exogenous. However, creditors can anticipate this agency problem. Knowing that the owner of the firm will take too much risk, they will accept to borrow to the firm only at premium. In the absence of any asymmetric information on the firm's risk management, this increased cost of capital will serve as an efficient incentive for the firm's owner to manage risk in an efficient manner. The creditors play here a role that is very similar to an insurer, by accepting to cover the downside risk of the firm against the payment of an actuarially fair premium implictly included in the borrowing rate. The problem with this story is that it may be hard for creditors to observe the degree of riskiness of the firm's business. The owner of the firm could promise to implement safer investment projects and to hedge insurable risks to the creditors to get a better borrowing rate. But it may be hard ex post for the owner to resist a substitution of the safe investments by riskier once, and to

reduce the insurance coverage of various insurable risks. One way to solve this agency problem for creditors and the associated commitment problem for the firm's owner would be to bundle their credit contract with a set of insurance contracts. Hedging removes the incentive of owners to substitute safe activities by risky ones, and can provide a credible signal to creditors that such expropriatory behavior will not be undertaken.

As explained by Doherty (2000), this agency problem also yields an underinvestment problem. Consider a solvent firm which contemplate the possibility to invest in a risk free project that yields some cost today C and some positive revenue Y next year. Suppose that it is socially efficient to implement the project because its net present value $-C + Y/(1 + r)$ is positive. Suppose now that the firm will remain solvent next year only with probability p. Then, it is optimal for the owner to invest only if $-C + pY/(1 + r)$ is positive. So, it may be possible for a rational firm not to invest in a socially efficient project because of the agency problem inherent to corporate governance. A better insurance coverage of the firm's underlying risk may help to solve this problem. Firms with a smaller growth opportunity have a larger p and have thus the most to gain from hedging.

Notice that same story can be given in an insurance context. Consider a "long-tail" risk whose potential losses would emerge only in a distant future, as is the case for many environmental damages (asbestos). A premium can be paid now in order to guarantee an indemnity in this distant future if a loss occurs. Because bankruptcy may occur in between, the owner pay the full cost of insurance, but he lay expect to get only a fraction of its benefit. Thus, considering the dynamic aspect of this agency problem yields another explanation of the low insurance demand by firms. A testable hypothesis here is that the firm's demand for long-tail risks is inversely related to the time for damages to emerge.

4.3 Bankruptcy costs

Bankruptcy may be very costly for the stakeholders of a firm. It entails direct costs, as accounting costs, legal fees and court fees. But it also entails indirect costs associated with the transfer of management rights to alternative managers who are not necessarily in a position to maximize the residual value of the firm, by lack of information and experience. In addition, these liquidators don't necessarily have the incentive to manage the insolvent firm

in an adequate way. There is no general picture here, since the incentive schemes implicit in bankruptcy laws are very diverse across countries. Finally, bankruptcy hurts the valuable reputation of the firm's owners.

When a loss occurs that triggers bankruptcy, the total loss for these stakeholders combines the actual loss plus the bankruptcy costs. Seen from ex-ante, this provides an additional incentive form them to purchase insurance. Hedging risk is a strategy to escape the costs associated to bankruptcy. Notice however that this costs are borne ex-post by creditors, since shares expire worthless when the firm becomes bankrupt. Thus, the existence of bankruptcy costs on the creditors' shoulders should not affect the preference of the firm's owners. However, the same point as in the previous section can be made: Creditors of potentially insolvent firms anticipate that they will bear the bankruptcy cost in case of insolvency. In the absence of an asymmetric information problem, they will therefore pass these expected costs to the owners through an increased interest rate on their credit. Thus, owners will internalize the cost of bankruptcy in their risk management. We see here again that there is an intimate relationship between the access to credit by firms and their insurance decision. Committing to insure their business risks is a way for firms to secure their access to credit markets, and to reduce their cost of capital. However, the existence of asymmetric information problems may limit the benefit of insurance. The possibility for creditors to have access to information on the firm's insurance decisions is a key element for the elimination of these agency problems.

4.4 The pecking order hypothesis

An important tested hypothesis in corporate finance is the so-called pecking order hypothesis, which states that firms have an implicit order of priority for the sources of financing of their investment project. Internal funding is the most preferred and the least costly source. Then comes external debt by banks or by emitting bonds. The least preferred and the most costly source of funding is external equity. External financing is more costly because of the asymmetric information problems already mentioned before.

The pecking order hypothesis implies that firms face a convex cost function for capital investments. As long as no loss occurs, the firm may extract enough resources from its business to finance new investment at low cost. But suppose alternatively that an uncovered loss occurs. This liquidity

shock raises the marginal cost of capital. Some projects that were attractive before the accident are not profitable anymore because of this. The decision to invest in them may be either postponed or even cancelled. This reduces the value of the firm. Froot, Scharfstein and Stein (1993) suggest that this loss may be large: for every dollar of sudden capital loss, firms reduce their investment budget by approximately 35 cents.

If the loss would have been covered by an insurance contract, the indemnity paid by the insurer would have preserved the internal funding of projects. Given the convexity of the capital cost function, hedging risk is a way to reduce the expected cost of capital. Insurance preserves internal sources of funding, reduces the need to call more external sources, and secures the investment in future profitable projects.

4.5 Agency costs between owners and managers

Contrary to what was assumed above, corporate decisions are usually not made by the corporation's owners, but rather by professional managers. This immediately raises some new agency problems. The outcome of the management is measured by the profitability of the firm, which is itself a function of the manager's talent and effort. The problem is that both talents and efforts are difficult to observe by the firm's owner. Higher efforts and better talents will lead to higher profit. The problem is that exerting efforts is costly for the manager, which raises a conflict of interest between the firm's owner and the firm's manager. This implies that the owner must provide incentives for the manager to exert effort. In the absence of risk, there is a one-to-one relationship between the manager's effort and the firm's profit. Thus, the effort can be indirectly observed through the realized profit.[4] The incentive scheme is then to pay the manager according to profit. If the bonus for high-profit managers exceeds their cost of effort, as may be the case with stock option plans for example, the interests of managers and owners are convergent, and the agency problems yields no inefficiency.

The problem with this story is that profits are affected by many other factors which are random and usually hard to observe by the owners. Then, it may be possible for an untalented and lazy manager to get a high profit

[4]We do not take into account of the possibility for the manager to falsify the firm's balance sheet.

by luck, or for a talented and active manager to end up with a low profit because of purely adverse chance. This has two consequences. First, this uncertainty may affect the risk-averse manager's incentive to exert effort.[5] Second, because managers are risk-averse, the uncertainty of their actual compensation (value of their stock options) reduces their welfare ex-ante. This will force owners to raise their expected manager's bonus to compensate for this risk. Insurance can alleviate this problem. It removes the noise that prohibits the owner to observe the manager's effort, and it serves as an insurance for the risk-averse manager's bonus. This allows the owner to reduce the expected bonus paid to the manager, and it raises the efficiency of the incentive scheme.

This story was a moral hazard tale. DeMarzo and Duffie (1995) provides an adverse selection tale for why firms may want to purchase insurance. Suppose that there are good and bad managers on the market, and that their quality is difficult to observe by owners. Because talents and profit are positively correlated, managerial rewards indexed on the firm's profit is a good way for owners to self-select their managers. Good managers will accept stock options, whereas bad managers will prefer a flat compensation scheme, as in the Rothschild-Stiglitz tale on insurance markets. But this signaling strategy is costly because of the risk aversion of the good managers who are forced to bear risk to signal their quality. By purchasing insurance, they do not only reduce their own compensation risk, but they also improve the quality of the signal by removing the noise. Insuring the firm's risk is a much more efficient way for talented managers to reveal their quality than the merit bonus system.

4.6 Incidental risk and core risk

Doherty (2000) mentions an additional argument explaining why corporations use to hedge risks that are not in their core business, i.e. incidental risks. The usual source of economic profit in a competitive markets is the comparative advantage that some firms have in the management of their risky activities. An oil company may want to retain the risk associated to the exploration of new oil fields, because that is where they have their core

[5]See Eeckhoudt and Gollier (2005) for a discussion of the effect of the uncertainty on the optimal effort of a risk-averse manager.

competence from which they extract their profit. However, in the process of undertaking these core business risks, the firm is forced to bear other risks, for which it has no comparative advantage to manage, as currency risks, liability risks, or safety risks for its employees. The firm cannot expect extra profit from bearing these noncore risks. On the contrary, insurers and reinsurers usually have a comparative advantage in managing them, and there is a market for a mutually advantageous risk transfer between firms and insurers. In short, insuring incidental risks reduces their cost.

5 Conclusion

In this paper, we have shown why risks may be costly for firms, but also why firms may find difficulty to insure them. A wide variety of arguments have been provided. Their heterogeneity suggests that these theory may be tested by observing the actual insurance demand by firms.

Firms have an incentive to insure risks because they face a convex tax scheme, which implies that hedging risk reduces the expected tax. Firm owners may also want to insure risks because it serves as a credible signal that they will not expropriate creditors by undertaking high-risk activities. Hedging risk is also good for reducing the likelihood of financial distress. This will improve their access to the credit market. Also, insurance is a strategy for firms to secure their access to cheap sources of funding their future investment, by pre-financing the reconstruction costs, and by reducing the intensity of liquidity shocks. The insurance of incidental risks is also useful for owners to solve the agency problem that they face with their risk-averse managers. It reduces the asymmetric information on both the manager's effort and the manager's quality.

But the insurance of corporate risks is confronted to the same well-known insurability problems than those of individual risks: transaction costs, adverse selection, ex-ante and ex-post moral hazard, crowding-out by solidarity, and ambiguous probabilities. The actual corporate decision to insure combines all these aspects in various degrees depending upon the probabilistic characteristics of the risks, the social, economic and legal environment of the firm, and the structure of its governance.

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