Chapter 1
Developments in Risk and Insurance Economics: The Past 40 Years

Henri Loubergé

Abstract The chapter reviews the evolution in insurance economics over the past 40 years, by first recalling the situation in 1973, then presenting the developments and new approaches which flourished since then. The chapter argues that these developments were only possible because steady advances were made in the economics of risk and uncertainty and in financial theory. Insurance economics has grown in importance to become a central theme in modern economics, providing not only practical examples to illustrate new theories, but also inspiring new ideas of relevance for the general economy.

Keywords Insurance economics • Insurance pricing • Economics of risk and uncertainty • Financial economics • Risk management • Asymmetric information

JEL Classification Numbers: D80, G22.

1.1 Introduction

In the early 1970s, some 40 years ago, the economics of risk and insurance was still embryonic. Indeed, when the International Association for the Study of Insurance Economics (known as the "Geneva Association") was founded in 1973, one of the main goals of its promoters was to foster the development of risk and insurance education in economics curricula. In particular, there existed then a clear need to develop an understanding for risk and insurance issues among the future partners of the insurance industry. It seemed also necessary to attract the attention of economists to risk and insurance as a stimulating and promising research field.

This survey is the revised and updated version of earlier surveys published as "Risk and insurance economics 25 years after" and "Developments in risk and insurance economics: the past 25 years" respectively in *The Geneva Papers on Risk and Insurance—Issues and Practices* (No 89, October 1998, pp. 540–567) and in *Handbook of Insurance*, G. Dionne (Ed.), Kluwer Academic Publishers, Boston, 2000, Chapter 1, pp. 3–33. I thank Georges Dionne, Louis Eeckhoudt, Harris Schlesinger and an anonymous reviewer for their comments on successive versions. The usual disclaimer applies.

H. Loubergé (✉)
GFRI and Swiss Finance Institute, University of Geneva, Switzerland
e-mail: henri.louberge@unige.ch

G. Dionne (ed.), *Handbook of Insurance*, DOI 10.1007/978-1-4614-0155-1_1,

At that time, some attempts to link insurance to general economic theory had already been made, but they were still scarce. The books written by Pfeffer (1956), Mahr (1964), Greene (1971), and Carter (1972), or the one edited by Hammond (1968), tried to bridge the gap. (Corporate) risk management started, at least in the USA, to be considered seriously as a branch of study—see Mehr and Hedges (1963) and Greene (1973) for early references. The main obstacle was obvious: traditional economic theory was based on the assumption of perfect knowledge—with some ad hoc departures from this assumption, as in the theory of imperfect competition or in Keynesian macroeconomics. In order to witness an integration of risk and insurance issues into general economics, the theory of risk had to develop and to gain a position at the heart of economic theory. The foundations were already at hand: the von Neumann and Morgenstern (1947) and Savage (1954) theory of behavior under uncertainty, the Friedman and Savage (1948) application to risk attitudes, Pratt's (1964) analysis of risk aversion, Rothschild and Stiglitz (1970) characterization of increases in risk, and the Arrow (1953) and Debreu (1959) model of general equilibrium under uncertainty. These approaches had already started to bring about a first revolution in the study of finance, with the Markowitz (1959) model of portfolio selection and the Sharpe (1964), Lintner (1965), and Mossin (1966) model of equilibrium capital asset pricing (the CAPM). With the benefit of hindsight, we know now that they did provide the starting point for the accomplishment of one of the Geneva Association's long-term objective: the integration of risk and insurance research into the mainstream of economic theory.

The purpose of this chapter is to remind the reader of the situation of insurance economics in 1973 (Sect. 1.2), and to summarize its main development since then in the three main areas of investigations that could be defined at that time: Optimal insurance and protection (Sect. 1.3); market equilibrium under asymmetric information (Sect. 1.4); and insurance market structure (Sect. 1.5). Section 1.6 introduces a personal bias toward financial economics by focussing on the new approaches which resulted from the growing integration of insurance and finance. Section 1.7 concludes. Due to limitations in space and time, two important related topics were omitted from this survey: health economics and social security. In addition, life insurance is only partially covered in Sect. 1.6. The discussion is mainly concentrated on risk and insurance economics issues as they relate to property–liability insurance.[1]

1.2 Insurance Economics in 1973

In 1973, the economic theory of insurance had already begun to develop on the basis of five seminal papers: Borch (1962), Arrow (1963a), Mossin (1968), Ehrlich and Becker (1972), and Joskow (1973).[2] All these papers were based on the expected utility paradigm. Following these papers, and more particularly the first two of them, a bunch of important papers were published. They were a signal that the elaboration of an economic theory of risk and insurance was under way.

1.2.1 Borch (1962)

In his 1962 *Econometrica* paper "Equilibrium in Reinsurance Markets," Karl Borch showed how Arrow's (1953) model of general equilibrium under uncertainty could be applied to the problem

[1]Note that all chapters appearing in the 2000 version of this *Handbook* are excluded from the reference list, on the expectations that the present version includes revised version of these surveys.

[2]Note that two of these six authors, Kenneth Arrow and Gary Becker, received later the highest distinction for economic research—the Nobel Prize in economics.

of risk-sharing among reinsurers. But generations of economists later learned that this insurance application had far-reaching implications for the general economy.[3] In 1953, Arrow had shown that financial markets provide an efficient tool to reach a Pareto-optimal allocation of risks in the economy. Nine years later, Borch's theorem[4] was showing how the mechanism could be organized in practice.

The main argument is the following. In a population of risk-averse individuals, only social risks matter. Individual risks do not really matter, because they can be diversified away using insurance markets (the reinsurance pool of Borch's paper). But social risks—those affecting the economy at large—cannot be diversified: they have to be shared among individuals. Borch's theorem on Pareto-optimal risk exchanges implies that the sharing rule is based on individual risk-tolerances (Wilson 1968). Each individual (reinsurer) gets a share in the social risk (the reinsurance pool) in proportion to its absolute risk-tolerance, the inverse of absolute risk-aversion. If all individual utility functions belong to a certain class (later known as the HARA[5] class, and including the most widely used utility functions), the sharing rule is linear. The above-mentioned CAPM, for long the dominant paradigm in finance theory, represents a special case of this general result.

In my view, Borch's paper provides the corner stone of insurance economics. It may be conveniently used to show how the insurance mechanism of risk-pooling is part of a more global financial mechanism of risk-allocation, and how a distinction may nevertheless be made between insurance institutions and other financial institutions.[6] For this reason, it may be used to clarify ideas on a hotly debated issue: the links between finance and insurance (see Sect. 1.6 below).

In the years until 1973, Borch's seminal contribution found its main insurance economics extensions in the papers by Arrow (1970) and Kihlstrom and Pauly (1971).[7] Arrow (1970) explicitly defined insurance contracts as conditional claims—an exchange of money now against conditional money in the future. Kihlstrom and Pauly (1971) introduced information costs in the risk-sharing model: they argued that economies of scale in the treatment of information explain why insurance companies exist. In 1974, Marshall extended further this analysis by introducing a distinction between two modes of insurance operations: reserves and mutualization (Marshall 1974). Under the reserve mode, aggregate risk is transferred to external risk-bearers (investors). With mutualization, external transfer does not apply, or cannot apply: aggregate losses are shared among insureds.

1.2.2 Arrow (1963a)

The article published in 1963 by Kenneth Arrow in *The American Economic Review* under the title "Uncertainty and the Welfare Economics of Medical Care" represents the second point of departure for risk and insurance economics. This work may be credited with at least three contributions. First, the article provided, for the first time, what has become now the most famous result in the theory of insurance demand: if the insurance premium is loaded, using a fixed-percentage loading above the actuarial value of the policy, then it is optimal for an expected utility maximizing insured to remain

[3] See Gollier (1992) for a review of the economic theory of risk exchanges, Drèze (1979) for an application to human capital, and Drèze (1990) for an application to securities *and* labor markets.

[4] Actually, Borch's theorem was already present in Borch (1960), but the latter article was primarily written for actuaries, whereas the 1962 *Econometrica* paper was addressed to economists.

[5] HARA = Hyperbolic Absolute Risk Aversion. As noted by Drèze (1990), the linearity of the sharing rule follows from the linearity of the absolute risk tolerance implied by hyperbolic absolute risk aversion.

[6] The question whether or not "institutions" are needed to allocate risks in the economy was tackled later in the finance literature.

[7] The applications of Borch's theorem in the actuarial literature are reviewed by Lemaire (1990).

partially at risk, i.e., to purchase incomplete insurance coverage. More specifically, Arrow proved that full insurance coverage above a deductible is optimal in this case. Second, Arrow also proved that when the insured and insurer are both risk-averse expected utility maximizers, Borch's theorem applies: the Pareto-optimal contract involves both a deductible and coinsurance of the risk above the deductible—a result later extended by Moffet (1979) and Raviv (1979), and more recently generalized by Gollier and Schlesinger (1996) and by Schlesinger (1997) under the less restrictive assumption of risk aversion.[8] Third, the paper was also seminal in the sense that it introduced asymmetric information into the picture. Arrow noted that transaction costs and risk aversion on the insurer's side were explanations for incomplete risk-transfer, but he also realized that moral hazard and adverse selection represented major obstacles for a smooth running of the insurance mechanism. By attracting the attention of economists to these problems, he paved the way to more focused work by Pauly (1968) and Spence and Zeckhauser (1971)—on moral hazard—and by Akerlof (1970)—on adverse selection.

1.2.3 Mossin (1968)

The paper by Jan Mossin, "Aspects of Rational Insurance Purchasing," published in 1968 in *The Journal of Political Economy*, is generally considered as the seminal paper on the theory of insurance demand—although some of Mossin's results were also implicit in Arrow (1963a) and explicit in another paper on insurance demand published the same year, but earlier, in the same journal (Smith 1968).[9] Mossin's paper is mainly famous to have shown: (1) that partial insurance coverage is optimal for a risk-averse expected utility maximizer when the insurance premium is such that a positive proportional loading applies to the actuarial value of the policy[10]; and (2) that insurance is an inferior good if the individual has decreasing absolute risk aversion (DARA). It was later pointed out (see below) that these strong results are respectively based on the implicit assumptions that the individual faces only one risk, and that the amount at risk is fixed (unrelated to wealth or income).

1.2.4 Ehrlich and Becker (1972)

In the modern theory of risk management, insurance is only seen as one of the tools available to manage risk. The whole set of tools may be decomposed into subsets according to the different steps of the risk management process. Insurance belongs to the set of risk-transfer tools and represents a very powerful financial mechanism to transfer risk to the market. Another subset corresponds to risk-prevention. Broadly, risk-prevention mechanisms may be classified under two headings: mechanisms intended to modify the probability of an event; and mechanisms intended to mitigate the consequences of an event. Ehrlich and Becker (1972) were the first to propose a rigorous economic analysis of risk prevention. They coined the terms *self-protection* and *self-insurance* to designate the two kinds of mechanisms and studied their relationship to "market insurance." For this reason, their paper may be seen as the first theoretical paper on risk management. Briefly, the paper provides three main results:

[8] More precisely, Schlesinger (1997) considers one version of Arrow's theorem: the case where the insurer is risk neutral and the insured is risk averse (risk aversion being defined by Schlesinger as preferences consistent with second-degree stochastic dominance). In this case a straight deductible policy is optimal whenever the insurer's costs are proportional to the indemnity payment.

[9] Optimal insurance coverage using a deductible was also analyzed by Pashigian et al. (1966) and by Gould (1969).

[10] Incomplete insurance may be obtained using a deductible or coinsurance (or both).

1. In the absence of market insurance, a risk averse expected utility maximizer will engage into self-protection and self-insurance activities, but the optimal "investment" in these activities depends on their cost. As usual, marginal benefit (in terms of higher expected utility) has to be weighted against the marginal disutility brought about by additional costs, so that complete elimination of the risk is not optimal in general.
2. Self-insurance and market insurance are substitutes: an increase in the degree of protection provided by the insurer induces a rational individual to reduce his investment into activities (or behavior) aimed at reducing the consequences of the insured event. Of course, this result is also of importance for the theory of moral hazard (see Sect. 1.4), but Ehrlich and Becker did not assume asymmetric information.
3. Self-protection and market insurance may be complement or substitutes, depending on the sensitivity of the insurance premium to the effects of self protection. Thus, the insurer can give to the insured an incentive to engage into self-protection activities (which reduce the likelihood of a loss) by introducing a link between the premium rate and the observation of such activities. This result is also of importance for the theory of moral hazard, and more generally for agency theory (the theory of relationships between an agent and a principal).

1.2.5 Joskow (1973)

The paper published by Paul Joskow in the *Bell Journal of Economics and Management Science* under the title "Cartels, Competition and Regulation in the Property-Liability Insurance Industry" represents the first successful attempt to submit the insurance sector to an economic evaluation. The paper assesses competition by analyzing market concentration and barriers to entry, it measures returns to scale, and discusses insurance distribution systems and rate regulation. By providing empirical results on these issues, it has provided a reference point for subsequent research on the sector. Briefly, Joskow found that the insurance industry was approximately competitive, that constant returns to scale could not be excluded, and that the direct writer system was more efficient than the independent agency system.

The five seminal contributions presented above prepared the ground for numerous developments. These may be grouped under three main headings: the demand for insurance and protection, economic equilibrium under asymmetric information, and insurance market structure. They are addressed in Sects. 1.3 to 1.5. It is striking to realize that many of these developments are not developments in insurance economics per se. They occurred within the wider domain of general economics, insurance providing in some cases an illustration of general results, and in other cases a stimulation to search for general results.[11]

1.3 Developments: Optimal Insurance and Protection

1.3.1 The Demand for Insurance

The observation of economic life shows that individuals generally do not insist to get partial coverage when they subscribe an insurance policy. As the insurance premiums are generally loaded (at least to

[11] The survey of developments presented in the next three sections draws on the excellent survey of insurance economics originally proposed by Dionne and Harrington (1992).

cover insurance costs), this is however the behavior which would be expected from them, according to Mossin's (1968) results. Moreover, insurance does not seem to be empirically an inferior good. If it was, insurance companies would be flourishing in the poorer nations and would be classified among the declining industries in the richer nations of the world. Moreover, recent empirical research on individual demand for insurance suggests that "higher income is (...) positively associated with insurance purchases of all kinds" (Cohen and Siegelman 2010, p. 69). This is, again, in contradiction with Mossin's analysis (given that absolute risk aversion is, indeed, empirically decreasing). One of the seminal papers at the roots of insurance economics has thus led to two paradoxes, and it is interesting to observe how theory was reconciled with factual observation.[12]

The second paradox (insurance is an inferior good) did not stimulate much research effort. Some scholars tried to dig into the idea by exploring the conditions under which insurance would be not only an inferior good, but also a Giffen good: see Hoy and Robson (1981), and Briys et al. (1989). But the interest remained limited. There are probably two reasons for that. First, following Arrow (1970), it was quickly recognized among economists that insurance is a financial claim. Thus it does not seem really appropriate to apply to insurance concepts which were derived to categorize consumption goods. Second, it has probably been noticed by most scholars that the condition under which Mossin's result obtains is not generally met in practice. Mossin assumes that the individual's wealth increases, but that the risky component of wealth remains unchanged. In reality, changes in wealth generally imply changes in the portion of wealth exposed to a risk of loss, and this is sufficient to resolve the paradox (see Chesney and Loubergé 1986).

The first paradox (partial coverage is optimal) has stimulated much more research effort. It has first been noticed that the result is not robust to changes in the pricing assumptions: for example, full insurance is optimal if the loading is a lump sum.[13] Some researchers pointed out that the result was either reinforced, or did not hold, if the behavioral assumptions were modified: see Razin (1976) and Briys and Loubergé (1985), or the nonexpected utility developments mentioned below. But the most interesting breakthrough came from enlarging the scope of the analysis. This was made in the early 1980s by deriving the logical conclusion from the observation that insurance is a financial claim. It had been recognized for long (Markowitz 1959) that the demand for financial assets should take place in a portfolio context, taking into consideration imperfect correlations across random asset returns. The same kind of reasoning was applied to insurance by Mayers and Smith (1983), Doherty and Schlesinger (1983a, 1983b), Turnbull (1983), and Doherty (1984). In this portfolio approach, which was soon accepted as an important improvement, the demand for insurance coverage on one risk should not be analyzed in isolation from the other risks faced by the decision-maker: insurance demand is not separable, even when the risks are independent (Eeckhoudt and Kimball 1992). When considering the insurance demand for one risk, one has to take into account the other risks, their stochastic dependence with the first risk, whether they are insurable or not, and under what conditions, whether some insurance is compulsory or subsidized, whether a riskless asset is traded, etc.: see, e.g., Schlesinger and Doherty (1985), von Schulenburg (1986), Kahane and Kroll (1985), Briys (1988), and Gollier and Scarmure (1994).[14] Thus, assuming that correlation is a sufficient measure of

[12]Other strange results were observed later on, for example an increased loss probability has an ambiguous impact on insurance purchasing if the insured has DARA preferences and the insurer adjusts the premium to take the increased loss probability into account (Jang and Hadar 1995).

[13]It is obvious that the paradox may be resolved if one introduces differential information. If the insured overestimates the probability (or the amount) of loss, full insurance may be optimal, even when the premium is loaded with a fixed proportional factor.

[14]On a related theme, see also Doherty and Schlesinger (1990) for the case where the insurance contract itself is risky, due to a nonzero probability of insurer default. The paper shows that full insurance is not optimal under fair insurance pricing, and that the usual comparative statics result from the single risk model do not carry over to the model with

dependence,[15] it may be optimal to partially insure a risk which is negatively correlated with an other risk, even if the premium is actuarial. Conversely, it may be optimal to fully insure a risk in spite of unfair pricing, if this risk is positively correlated with an other uninsurable risk. In a portfolio context, incomplete markets for insurance provide a rationale for full insurance of the insurable risks. Mossin's paradox can thus be resolved by changing the perspective, instead of changing the analytical model (the expected utility model).[16]

Eeckhoudt and Kimball (1992) introduced the concept of prudence into the analysis of optimal insurance purchasing under backgroud risk and pointed out that the demand for insurance for one risk was not independent of the background risk, even when the two risks are independent. Building on these premises, several papers checked the conditions under which optimal insurance demand under background risk has desirable comparative statics properties, such as an increase in optimal insurance coverage when the insured or uninsured risks increase, or whether a deductible policy remains optimal under background risk: see Meyer (1992), Dionne and Gollier (1992), Eeckhoudt et al. (1991, 1996), Gollier and Schlesinger (1995), Gollier (1995), Gollier and Pratt (1996), Gollier and Schlee (1997), Tibiletti (1995), Guiso and Jappelli (1998), Meyer and Meyer (1998a), and Mahul (2000).

More recently, the insurance model with background risk has been extended to the case where the uninsurable risk is nonpecuniary. This is the case, for example, if the background risk represents a state of health. The problem may be analyzed using state-dependent utility functions or introducing a second argument in the decision maker's utility function, besides wealth. Using the second approach, Rey (2003) has demonstrated that the impact of the nonfinancial risk on insurance demand depends not only on the relationship between the two risks but also on the impact of the background risk on the marginal utility of wealth. For example, if the marginal utility of wealth increases under occurence of a nonfinancial loss (some degree of disability, for example)[17] and if the two risks are positively correlated, then insurance demand will be increased. Full insurance becomes possible, even with a loaded premium. But full insurance with a loaded premium may also obtain if the two risks are negatively correlated and the marginal utility of wealth is lower under occurence of a nonfinancial loss.[18] The range of possibilities for contradicting Mossin's first proposition (in Sect. 1.2.3 above) becomes wider.

1.3.2 Insurance, Consumption, and Saving

Research integrating joint optimal decisions on consumption, saving, and insurance represents a different research program, which was addressed by Moffet (1977) and Dionne and Eeckhoudt

default risk. Their work was extended by Cummins and Mahul (2003) to the case where the insurer and policyholder have divergent beliefs about the insurer default risk.

[15] In a recent paper, Hong et al. (2011) argue that correlation is not an adequate measure of stochastic dependence when expected utility is used. Turning to more general notions of positive and negative dependence, and focussing on coinsurance, they show that the individual will purchase less than full (more than full) insurance if and only if the insurable risk is positively (negatively) expectation dependent with random initial wealth.

[16] These theoretical advances closely followed similar advances in the theory of risk premiums under multiple sources of risk: Kihlstrom et al. (1981), Ross (1981), and Doherty et al. (1987). This literature on optimal insurance in presence of a background risk has also close links to the literature on the demand for a risky asset which was pioneered by Arrow (1963b) in a single risk setting and developed later to consider the impact of background risks: see, e.g., Tsetlin and Winkler (2005) and Li (2011) for recent contributions.

[17] This case corresponds to a negative cross-derivative of the two-attribute utility function ($u_{12} \leq 0$). Eeckhoudt et al. (2007) show that this is equivalent to "correlation aversion," the aversion to losses affecting simultaneously the two attributes of utility (health and wealth for example).

[18] Following Eeckhoudt et al. (2007), the individual is then "correlation loving." For him, in this case, purchasing more insurance against a loss in wealth helps to mitigate the adverse impact of a negative correlation between the two risks.

(1984). The latter authors have shown that investing in the riskless asset is a substitute to insurance purchasing. This work was generalized by Briys (1988) using a continuous-time model. More recently, Gollier (2003) has considered the impact of time diversification on optimal insurance demand in a dynamic framework, under the assumption of no serial correlation in risks. He shows that mainly liquidity constrained individuals will insure largely. Wealthy individuals will take advantage of time diversification to accumulate buffer stock wealth and avoid the costs due to loaded insurance prices.

A related avenue of research concerns the joint determination of insurable asset purchases and optimal insurance coverage: see Meyer and Ormiston (1995), Eeckhoudt et al. (1997), Meyer and Meyer (2004), and Loubergé and Watt (2008) for recent work along this line.[19] In the first of these papers, the individual is endowed with riskless wealth and with a risky insurable asset, but insurance can only be paid for by selling a part of the risky asset. Hence, the model differs from Mossin (1968) where insurance is paid out of riskless wealth. However, because an increase in wealth impacts only riskless wealth, insurance remains an inferior asset under DARA. Eeckhoudt et al. (1997) generalize the previous work by considering an individual who allocates some nonrandom wealth to the purchase of a safe asset, a risky asset, and an insurance contract to cover the risky asset. The optimal demands for the risky asset and for insurance coverage are determined jointly and paid out of risk-free wealth. As the insurance indemnity is not linear,[20] it may be optimal to keep some wealth in the risk-free asset. As expected, it turns out that insurance and holding the riskless asset are substitutes. However, the generality of the model does not allow the authors to derive clear comparative statics results. In particular, "increases in initial wealth can lead to increases or decreases in the insurance level and to increases or decreases in the holding of the risky asset, (...) even when the decision maker is decreasingly risk averse" (p. 26). Thus Mossin's second paradox is not confirmed: insurance is not necessarily inferior under DARA. Further, Meyer and Meyer (2004) considered the case where the individual is endowed with a composite portfolio of risky and riskless assets in fixed proportion. The risky asset may be insured without changing the proportions of the two assets held. Under these peculiar circumstances, insurance turns out to be normal whenever *relative* risk aversion is nondecreasing. In addition, the authors prove that insurance is ordinary (not Giffen) if relative risk aversion is less than or equal to 1, a condition already derived in previous work based on the standard model (Hoy and Robson 1981). The same restrictive condition is also pivotal—as in Meyer and Ormiston (1995) and in Eeckhoudt et al. (1997)—to determine whether insurance demand will increase or not in reaction to an increase in the size of the loss. More recently, Loubergé and Watt (2008) addressed the same issues by focussing on the case where the riskless asset is dominated and all available wealth is invested in a risky and insurable asset (an investment opportunity), partly to purchase the asset, partly to finance insurance purchasing. In their setting, coinsurance is allowed, partial insurance is optimal when the premium is loaded and may be optimal when insurance is fair. The fraction of the investment subject to a loss is a very important parameter in the model, along with risk aversion. If the fraction is low enough, no insurance is optimal. With a larger fraction, and positive insurance, insurance is normal if *relative* risk aversion is nondecreasing. But even with decreasing relative risk aversion, insurance is still normal if the proportion of the investment subject to a loss is higher than the rate at which relative risk aversion decreases.[21] Insurance demand increases unambiguously if the percentage loss increases. But, when the loss probability increases and the insurer simultaneously adjusts the premium rate to take this change into account, the results are less clear-cut: it turns out that the demand for insurance increases if the relative risk aversion is constant

[19] The following developments on this topic borrow from the literature review in Loubergé and Watt (2008).

[20] Coinsurance must be excluded to avoid corner solutions of either no holding of the riskless asset or zero demand for insurance. Meyer and Meyer (1998b) address the specific case of deductible insurance.

[21] In this case, with increasing wealth, the rate of increase of the possible loss amount is higher than the rate of decrease of relative risk aversion.

and less than or equal to 1, but may also increase for values of constant relative risk aversion larger than 1 depending on the relationship between this value and the value of the percentage loss to which the asset is exposed.[22] Obviously, changes in risk aversion complicate the analysis when purchasing of an insurable risky asset and insurance are considered simultaneously, instead of separately.

1.3.3 Self-protection and Self-insurance

Research on risk prevention (self-protection and self-insurance activities, in the Ehrlich and Becker 1972, sense) has developed more slowly during the 1980s, but has received increased attention recently. The earlier important contributions came with Boyer and Dionne (1989b) who noted that self-insurance leads to stronger changes in risk than self-protection (see also Chang and Ehrlich 1985), and with Dionne and Eeckhoudt (1985) who showed that increased risk aversion leads to more self-insurance, but obtained the surprising result that an increase in risk aversion does not necessarily result in higher self-protection, everything else constant.[23] Briys and Schlesinger (1990) proved later that these results are quite robust to a change in the model setting, e.g., introducing state-dependent utility functions or a random initial wealth. As noted by them and by Sweeney and Beard (1992), this is due to the fact that, in contrast to insurance, "expenditures on self-protection do not merely trade income in one state of the world for income in another... Self-protection reduces income in all states." The expected utility impact of this lost income in all states must be weighted against the utility impact of a lower loss probability. More precisely, self-protection does not reduce risk in the Rothschild and Stiglitz (1970) sense. As shown by Briys and Schlesinger (1990), "an increase in the level of self-protection causes both a mean-preserving spread *and* a mean-preserving contraction in the wealth distribution, with the spread occurring at lower wealth levels and the contraction at higher wealth levels" (p. 465). For this reason a more risk-averse individual does not necessarily invest more in self-protection. Eeckhoudt and Gollier (2005) showed that introducing prudence into the picture does not lead to a more intuitive result.[24] More prudence (in the Kimball (1990), sense) does not lead to more self-protection. In particular, if the optimal self-protection expenditure of a risk neutral agent is such that her probability of loss is $p_n \geq 1/2$, a risk averse and prudent agent spends less on self-protection than the risk-neutral agent (see also Dachraoui et al. 2004; Dionne and Li 2011, for comparable results). The reason is that prevention has a current monetary cost (it is defined as an expenditure) and a more prudent individual wants to increase saving to hedge against future contingencies.

Dionne and Eeckhoudt (1988) also investigated the effects of increasing risk on optimal investment in self-protection activities, while wealth effects on self-insurance and self-protection were analyzed by Sweeney and Beard (1992) and by Lee (2005) in a two-state model. For a given loss, self-insurance turns out to be inferior under DARA, whereas the effect of wealth on self-protection expenses is ambiguous.[25] Lee (2010) extended the self-insurance model to a multiple-state setting and showed

[22] Using Mossin's (1968) approach, Jang and Hadar (1995) obtain that the effect of an increase in the probability of loss is in this case indeterminate if the utility function displays DARA, and that the demand for insurance decreases with CARA or IARA utility.

[23] Jullien et al. (1999) showed later that "self-protection increases with risk aversion if and only if the initial probability of loss is low enough."

[24] See also Courbage and Rey (2006) for an extension of this result to the case of two-argument utility functions, wealth, and health.

[25] The effect of wealth on self-protection expenses is null under CARA and it depends on the level of the loss probability under DARA and IARA.

that results from the two-state model do not carry over to a multiple-state model. Self-insurance may be normal under DARA if several loss states are possible.

But in contrast with most other domains of risk and insurance economics, the analysis of prevention was not replaced, until recently, in a broader multiple risks context. Steps in that direction had been made by Briys and Schlesinger (1990, see above) and by Briys et al. (1991) with their analysis of "risky risk management." More recently, Dachraoui et al. (2004) noted that their analysis of self-protection for a "mixed risk averse" agent *à la* Caballé and Pomansky (1996) applies as well when the agent faces a background risk. An important additional step on this issue was made by Lee (2012) in his analysis of self-protection under background risk. He considers two kinds of self-protection: self-protection effort and monetary investment in self-protection devices. He obtains that an individual facing a background risk will exert more self-protection effort than the same individual without background risk. Concerning monetary investment in self-protection, he is also able to show that the presence of a background risk will increase self-protection, if the self-protection expenditure is paid out of income not out of wealth, and if wealth and consumption are complements.[26] Recently also, Courbage and Rey (2012) investigated the impact of background risks on optimal self-protection expenditures in a two-period model. They show that a prudent individual does not necessarily exert more effort in presence of a background risk. In a two-period model, the results differ depending on whether the background risk is introduced in the first or the second period, and depending on whether the background risk arises in the loss or no-loss state of nature.

1.3.4 The Demand for Liability Insurance

Liability risk raises particular issues that were addressed in a specific branch of the insurance economics literature, at the interface between law and economics. An economic agent (*the injurer*) may be made liable for the monetary and non-monetary losses he or she imposes on another agent (*the victim*). The losses are random but are in general influenced by the decisions of the injurer regarding his/her level of potentially harmful activity and his/her level of care. The injurer can contract liability insurance to cover the risk of being sued by the victim(s). The availability of insurance is not without influence on the injurer's decisions regarding the levels of activity and care, as has been known since Ehrlich and Becker (1972). But the specificity of liability insurance arises from the possibility that the losses imposed on the victim(s) exceed the injurer's wealth. In this case, the injurer is "judgment proof": he or she cannot be forced to bear the full monetary consequences of the losses resulting from his or her activity. This has an influence on the injurer's optimal level of care and insurance demand.

The impact of the "judgment proof problem" on the demand for liability insurance was first analyzed by Sinn (1982). He remarked that when injurers are socially guaranteed a minimum "subsistence" level of wealth, a kink appears in their utility function. Such a kink breaks the overall concavity of the function, with the result that a risk averse injurer may rationally choose not to purchase any liability insurance, even if the insurance premium is actuarially fair. Whether insurance will be purchased or not depends on the injurer's initial wealth, on the socially guaranteed minimum subsistence level and on the size of the loss, among other usual influences such as risk aversion and insurance price. If insurance is purchased, it will be full insurance if the premium is actuarially fair (no proportional loading applies) and partial insurance if the premium entails a proportional loading—as

[26]Note that all this literature on self-insurance and self-protection has been driving away from the study of the links between insurance demand and prevention. In addition, except for the recent paper by Lee (2012), it has focussed on the case where prevention implies a monetary cost (prevention expenditures), instead of the case where prevention implies an "effort" producing a direct loss in utility—presumably because the analysis of the latter case is more straightforward.

expected from Mossin's (1968) results. However, a noteworthy implication of the analysis is that insurance demand for liability insurance is an increasing function of the injurer's initial wealth, even if the injurer's preferences are DARA and the possible loss is fixed, a result opposite to the one obtained by Mossin in the property insurance case.

Huberman et al. (1983) emphasized that the reluctance of injurers to purchase liability insurance derives from the fact that the insurance premium takes into account a range of (high) losses to which injurers are not exposed if such losses exceed the value of their assets (or the difference between their assets and the socially guaranteed minimum subsistence level). Using the example of a 3-state model and assuming actuarially fair insurance pricing, they show that when a possible large loss exceeds the injurer's assets it is preferable for the injurer to set a limit on the insurance indemnity and remain partially covered, even for losses that do not imply bankruptcy. The risk-spreading function of insurance is hampered.

Liability insurance and the judgment proof problem were comprehensively analyzed by Shavell (1986) in a model where the potential injurer decides simultaneously on insurance purchasing and on the optimal level of care under two possible legal frameworks: strict liability and the negligence rule.[27] Under strict liability, the results depend on whether the insurer can observe the insured's level of care of not. With perfect information, the insurer can adjust the premium to the level of care. In this case, if the injurer's initial wealth exceeds some threshold, full insurance and an efficient level of care are both optimal. As care is observable and impacts the insurance premium, the insured gains from adopting the efficient level of care, whereas in the absence of insurance, a lower level of care would have been optimally chosen, due to the judgment proof problem. If the injurer's initial wealth is below the threshold, no insurance is purchased and the level of care is zero or reduced below the efficient level.

These results make a strong case for imposing compulsory liability insurance, but they are conditioned on the perfect observability assumption. If care exercised by the injurer is not observable by the insurer, either no insurance is chosen (in a wider range of injurer's wealth), or insurance is partial, with a sub-efficient level of care. In this situation, the case for compulsory liability insurance is not made. A tension arises between risk-spreading and appropriate incentives to avoid losses.

When the negligence rule holds, care is assumed to be observable. In this case, it is optimal for the injurer not to purchase any insurance and to exercise the optimal no-insurance level of care when the judgment proof problem arises: either no care at all if initial wealth is below a first threshold; an increasing level of care if initial wealth is beyond this threshold but below a second threshold; and the efficient level of care if initial wealth is beyond the second threshold. The reason is that it is useless to purchase insurance if the injurer applies the appropriate level of care. Not applying this level and purchasing coverage for the risk of being liable would be more costly.[28] Of course, the result under the negligence rule hinges on the belief that the injurer will not be judged liable for the loss imposed on the victim(s) if the efficient level of care was chosen. Judicial uncertainty is ruled out (see Shavell 2000, for more on this issue). More generally, the results presented above rely on the assumption that the legal tort liability/liability insurance system is efficient, which has been hotly debated, particularly in the wake of the US liability insurance crisis of the mid-1980s (see Danzon and Harrington 1992, for a early survey of liability insurance issues).

[27] Under the negligence rule, an injurer cannot be made liable for the losses imposed on a victim if the injurer has applied the appropriate level of care. In theoretical work, the appropriate level of care is the socially efficient level of care optimally chosen by a risk averse potential injurer if the judgment proof problem does not arise. This level balances the marginal benefits and marginal cost of care.

[28] In addition, the injurer would run the risk of being denied indemnification by the insurer if it turned out *ex post* that the level of care was unappropriate.

1.3.5 Other Contributions

Other work in the theory of optimal insurance concerns:

1. The specific issues raised by the corporate demand for insurance: these issues will be considered in Sect. 1.6 below.
2. The focus on anomalies observed in actual insurance purchasing behavior (Kunreuther and Pauly 2005).
3. The extension of the expected utility model to take into account state-dependent utility functions. One can thus introduce into the analysis important observations from reality. For example, the observation that the indemnity paid by the insurer cannot provide complete compensation for a non monetary loss, such as the loss of a child, or the observation that the marginal utility of wealth is different under good health and under disability: see Arrow (1974), Cook and Graham (1977), and Schlesinger (1984) for important papers along this line. This line of research is however related to, and generalized by, the recent literature on insurance purchasing under multi-attribute utility functions (see above: Rey 2003).
4. The replacement of the expected utility model with recent generalizations, grouped under the heading "nonexpected utility analysis." This research program has already produced several interesting results. Using the distinction between risk aversion of order 1 and risk aversion of order 2,[29] Segal and Spivak (1990) have shown that Mossin's (1968) result on the optimality of partial coverage under a loaded insurance premium does not hold necessarily if risk aversion is of order 1 (see also Schlesinger 1997). Now, risk aversion of order 1 may occur under the expected utility model (if the utility is not differentiable at the endowment point), or under some generalizations of this model, such as Yaari (1987) dual theory, or Quiggin (1982) rank-dependent expected utility theory. In particular, using Yaari's model, Doherty and Eeckhoudt (1995) have shown that only full insurance or no insurance (corner solutions) are optimal with proportional insurance, when the premium is loaded.[30] Karni (1992) has shown that Arrows's (1963a) result on the optimality of a deductible policy is robust to a change in behavioral assumptions if the modified model satisfy some differentiability conditions, which are met by Yaari (1987) and Quiggin (1982) models. Indeed, Schlesinger (1987) has shown that this result is very robust to a change of model. Konrad and Skaperdas (1993) applied Ehrlich and Becker (1972) analysis of self-insurance and self-protection to the rank-dependent expected utility model. Schlee (1995) confronted the comparative statics of deductible insurance in the two classes of model. So far, the most comprehensive attempt to submit classical results in insurance economics to a robustness test by shifting from expected utility to nonexpected utility can be found in Machina (1995). He uses his generalized expected utility analysis (Machina 1982) and concludes that most of the results are quite robust to dropping the expected utility hypothesis. However, the generality of his conclusion is challenged by Karni (1995) since Segal and Spivak (1990) have shown that Machina's generalized expected utility theory is characterized by risk aversion of order 2.

The demand for insurance under background risk in a nonexpected utility setting was analyzed by Doherty and Garven (1995) using Yaari (1987) dual choice theory. They show that an interior solution (partial insurance) *may* be obtained under proportional coverage and a loaded insurance premium if an independent background risk is present (full insurance remains optimal if the premium is fair). Dropping the independence assumption, they note that the likelihood to get a corner solution increases.

---

[29]The orders of risk aversion, as defined by Segal and Spivak (1990), rest on the behavior of the risk premium in the limit, as the risk tends toward zero.

[30]This result is reminiscent of the same result obtained under Hurwicz's model of choice under risk: see Briys and Loubergé (1985).

But, qualitatively, the effects of introducing positively or negatively correlated background risks are the same as under expected utility. More generally, Schlesinger (1997) has shown that introducing an independent background risk in a decision model with risk aversion does not change the predictions obtained under a single source of risk: full insurance is optimal under a fair premium; partial or full insurance may be optimal under a loaded premium; and a deductible policy remains optimal.

1.4 Developments: Markets Under Asymmetric Information

The Arrow (1953) model shows that a market economy leads to a general and efficient[31] economic equilibrium—even under uncertainty—if the financial market is complete, i.e., provided the traded securities and insurance contracts make possible to cover optimally any future contingency. This is an important result since it extends to the case of uncertainty the classical result on the viability and efficiency of a free market economy.

However, as Arrow himself noticed in his 1963 article (see above), optimal coverage is not always available in insurance markets due to various reasons. Among these reasons, asymmetric information has received much attention in the economic literature and has been generally discussed under two main headings: moral hazard and adverse selection. Moral hazard exists when (1) the contract outcome is partly under the influence of the insured, and (2) the insurer is unable to observe, without costs, to which extent the reported losses are attributable to the insured's behavior. Adverse selection occurs when (1) the prospective insureds are heterogeneous, and (2) the risk class to which they belong cannot be determined a priori by the insurer (at least not without costs), so that every insured is charged the same premium rate.[32] Clearly, asymmetric information is a source of incompleteness in insurance markets: e.g., a student cannot be insured against the risk of failing at an exam; a healthy old person may not find medical insurance coverage at an acceptable premium, etc. For this reason, a free market economy may not be efficient, and this may justify government intervention.

1.4.1 Moral Hazard

Economists make a distinction between two kinds of moral hazard, depending on the timing of the insured's action. If the latter occurs before the realization of the insured event, one has *ex ante* moral hazard, while *ex post* moral hazard exists when the insured's action is taken after the insured event.[33]

Ex ante moral hazard was studied by Pauly (1974), Marshall (1976), Holmstrom (1979), and Shavell (1979), among others. They showed that insurance reduces the incentive to take care when

[31] An economic equilibrium is efficient if it is Pareto optimal: it is impossible to organize a reallocation of resources which would increase the satisfaction of one individual without hurting at least one other individual. The first theorem of welfare economics states that any competitive equilibrium is Pareto optimal, and the second theorem states that a particular Pareto optimum may be reached by combining lump sum transfers among agents with a competitive economic system. In an efficient equilibrium, market prices reflect social opportunity costs.

[32] In an interesting article on the history of the term "moral hazard" Rowell and Connelly (2012) note that the concepts of moral hazard and adverse selection have often been confused in the insurance literature. They also remark that this literature tends to attribute a pejorative meaning to "moral hazard," often associated with fraud, in contrast to the economic literature which focuses on incentives and maintains that "moral hazard has in fact little to do with morality" (Pauly 1968).

[33] *Ex post* moral hazard is particularly important in medical insurance, where claimed expenses are dependent on decisions made by the patient and the physician once illness has occurred.

the insurer is unable to monitor the insured's action. Dionne (1982) pointed out that moral hazard is also present when the insured event results in non-monetary losses, for example the loss of an irreplaceable commodity. Quite generally, partial provision of insurance is optimal under moral hazard. More specifically it was demonstrated that uniform pricing is not optimal when the insured's behavior affects the probability of a loss. The equilibrium premium *rate* is an increasing function of the amount of coverage purchased (nonlinear pricing): see Pauly (1974). In addition, under moral hazard in loss reduction, the optimal contract is conceived such as to make the degree of coverage a nonincreasing function of the amount of losses, large losses signaling careless behavior by the insured. Small losses are fully covered, but losses exceeding a limit are partially covered (Winter 1992, proposition 4). Shavell (1982, 1986) extended the study of moral hazard to the case of liability insurance. He showed that making liability insurance compulsory results in less than optimal care.[34]

The existence of long-term (multi-period) contracts does not necessarily mitigate the effect of moral hazard. Under the infinite period case, Rubinstein and Yaari (1983) proved that the insurer can eliminate the moral hazard problem by choosing an appropriate experience rating scheme that provides an incentive to take care. But the result does not, in general, carry over to the finite period case (Winter 1992). In addition, the possibility for the insured to switch to an other insurer makes a penalty scheme difficult to enforce in truly competitive insurance markets, where insurers do not share information on prospective insureds.[35]

Ex post moral hazard was first pointed out by Spence and Zeckhauser (1971), and studied later by Townsend (1979) and Dionne (1984). In this case, the nature of the accident is not observable by the insurer, who has to rely on the insured's report or engage in costly verification.[36] Mookherjee and Png (1989) showed that random auditing represents the appropriate response by the insurer in this situation. Their work was extended by Fagart and Picard (1999) who investigated the characteristics of optimal insurance under random auditing. Using a deterministic auditing policy, Bond and Crocker (1997) obtained that the optimal insurance contract includes generous payment of easily monitored losses and undercompensation for claims exhibiting higher verification costs.

The consequences of moral hazard for the efficiency of a market economy were studied by Helpman and Laffont (1975), Stiglitz (1983), Arnott and Stiglitz (1990), and Arnott (1992), among others. They showed that a competitive equilibrium may not exist under moral hazard, and that the failure to get complete insurance coverage results at best in sub-efficient equilibrium. This is due to the fact that "moral hazard involves a trade-off between the goal of efficient risk bearing, which is met by allocating the risk to the insurer, and the goal of efficient incentives, which requires leaving the consequences of decisions about care with the decision maker." (Winter 1992, p. 63). However, government intervention does not necessarily improve welfare in this case. This depends on government information, compared with the information at the disposal of private insurers. Arguments may be put forward in favor of a taxation and subsidization policy providing incentives to avoid and reduce losses, but public provision of insurance does not solve the moral hazard problem (Arnott and Stiglitz 1990).

Moral hazard has become a popular theme in economics, not only because its presence in insurance markets results in less than optimal functioning of any economic system, but also because it is a widespread phenomenon. As Winter (1992) notes, moral hazard can be defined broadly as a conflict

[34]Note that moral hazard is also present in the insurer–reinsurer relationship (see Jean-Baptiste and Santomero 2000). The success of index products in insurance securitization is partly due to the fact that they remove the moral hazard from the relationship between insurers and providers of reinsurance coverage (Doherty and Richter 2002).

[35]The situation is of course different in monopolistic insurance markets (see Boyer and Dionne 1989a) or in markets where retrospective rating is mandatory.

[36]At some point, the moral hazard problem becomes a fraud problem—see Picard (1996), Crocker and Morgan (1998), the special issue on fraud in *The Journal of Risk and Insurance*, September 2002 (Derrig 2002), and more recently Dionne et al. (2009).

of interests between an individual (behaving rationally) in an organization, and the collective interest of the organization. Insurance markets provide the best illustration for the effect of moral hazard, but the latter is also observed in labor relationships, in finance contracts, and quite generally in all circumstances where the final wealth of a *principal* is both uncertain and partially dependent upon the behavior of an *agent* whose actions are imperfectly observable: for example, in a corporation, the wealth of the firm's owners (stockholders) is partly dependent upon the actions of the manager; in judicial procedure, the final outcome is partly dependent upon the efforts of the lawyers; in a team, the success of the team is partly dependent on the individual effort of the members, etc. All these situations were studied in the economic and financial literature under the headings of *principal-agent relationships* or *agency theory*, with close connections to the literature on moral hazard in insurance: in both cases, the objective is to define the optimal "incentive contract" to mitigate the effect of asymmetric information, and to study the consequences of different arrangements on deviations from efficiency: see Ross (1973), Radner (1981), Lambert (1983), and Grossman and Hart (1983) for canonical references. See also Allen (1985), Fudenberg and Tirole (1990), and Chiappori et al. (1994) for research introducing credit markets and saving into the analysis. Similarly, the consequences for general economic equilibrium of market incompleteness brought about, among other causes, by moral hazard has become a central theme of research in economics: see, e.g., Polemarchakis (1990). On the moral hazard issue, at least, developments in insurance economics were closely related to developments in general economic theory.

Turning to empirical work, and focussing on moral hazard in insurance contracts, evidence for an impact of moral hazard on insured losses has been documented in several studies taking advantage of natural experiments provided by changes in legislation, starting with Dionne and St-Michel (1991) for workers' compensation and continuing with Cohen and Dehejia (2004) for automobile insurance, as well as Chiappori et al. (1998) and Klick and Stratmann (2007) for health insurance. In contrast, Abbring et al. (2003) do not find any evidence of moral hazard in multi-period data provided by the French system of *bonus-malus* in automobile insurance. A *malus*, which results from prior accident history and increases the cost of insurance for the policyholder, does not lead to a significant reduction in insured losses. In addition, even if a drop in insurance claims is observed following the introduction of experience rating, evidence from Canada suggests that much of the decline is due to an increased incentive not to report claims (see Robinson and Zheng 2010). In this case, policy changes introduced to address the *ex ante* moral hazard issue stimulate the development of a kind of *ex post* moral hazard.[37] In the case of fraud—an extreme version of moral hazard—Hoyt et al. (2006) report that antifraud laws introduced in the USA in the period 1988–1999 had mixed effects on automobile insurance fraud. Some laws had no statistically significant effects and others actually increased fraud. To sum up, although there are strong theoretical reasons to believe that moral hazard represents a major issue in insurance, and experience rating a powerful tool to deal with it, the empirical evidence so far is not compelling. This is probably due to the difficulty to set up tests that isolate the moral hazard from other influences, given the information limits on actual incentives and behavior among insureds.

1.4.2 Adverse Selection

A central development in the study of adverse selection was the paper by Rothschild and Stiglitz (1976). This paper assumed two classes in the insured population: "good risks" and "bad risks."

[37] Dionne et al. (2011) claim to have found evidence of moral hazard in the statistical relationship between traffic violations and accumulated "demerit points" in the system of driving license suspension threat introduced in Quebec in 1978, but they do not find such evidence when they test the effect of the 1992 insurance pricing scheme on the relationship between "demerit points" and car accidents: road infractions were reduced by 15 %, with no significant effect on car accidents.

The two classes differ only with respect to their accident probability. The authors showed that a competitive insurance market does not necessarily reach an equilibrium under adverse selection, and that, if it does, the "good risks" suffer a welfare loss. More specifically, under the assumptions of the model, including the assumption of myopic behavior by insurers (pure Cournot-Nash strategy), equilibrium obtains if the proportion of good risks in the economy is not "too large." The equilibrium situation involves the supply of discriminating contracts providing full insurance at a high price to the bad risks and partial coverage at a low price to the good risks.[38] Compared to the symmetric information case, the bad risks get the same expected utility, but the good risks suffer a welfare loss. The policy implication of the model is that, in some circumstances, insurance markets may fail, and monopolistic insurance (under government supervision) or compulsory insurance may be justified as a second best.[39]

Extensions of the basic Rothschild–Stiglitz model are due to Wilson (1977), Spence (1978), and Riley (1979), who dropped the assumption of myopic behavior by insurers. Then, an equilibrium exists always, either as a separating equilibrium (Riley, Wilson), or as a pooling equilibrium (Wilson). Moreover, Spence showed that this equilibrium is efficient if the discriminating insurance contracts are combined with cross-subsidization among risk classes, the low risks subsidizing the high risks.[40] More recent extensions concern the case where the individuals face a random loss distribution (Doherty and Jung 1993; Doherty and Garven 1995; Landsberger and Meilijson 1996; Young and Browne 1997), the case where they differ with respect to both accident probability and degree of risk aversion (Smart 2000), the case where some of them are overconfident (Sandroni and Squintani 2007), and the case where they are exposed to multiple risks, or background risk (Fluet and Pannequin 1997; Crocker and Snow 2008). Allard et al. (1997) have also shown that the Rothschild–Stiglitz results are not robust to the introduction of transaction costs: for arbitrary small fixed set-up costs pooling equilibria may exist in a competitive insurance market, and high risk individuals (rather than low risk individuals) are rationed. In addition, it is important to note that a separating equilibrium may be invalidated if insureds have the opportunity to purchase coverage for the same risk from different insurers. For this reason, Hellwig (1988) extended the model to take into account the sharing of information by insurers about the policyholders.

These models were empirically tested by Dahlby (1983,1992) for the Canadian automobile insurance market, and by Puelz and Snow (1994), who used individual data provided by an automobile insurer in the state of Georgia. Both studies reported strong evidence of adverse selection and provided empirical support for the separating equilibrium outcome; in addition, the former study found evidence of cross-subsidization among risk classes, whereas the latter found no such evidence.

However, more recent studies returned less clear results: for instance, focussing on automobile insurance, Chiappori and Salanié (2000) reported that drivers with comprehensive insurance have no statistically different accident frequency compared to drivers with minimum coverage, controlling for all observable characteristics. Richaudeau (1999) and Saito (2006) obtained similar conclusions. Dionne et al. (2001) showed that the results of Puelz and Snow (1994) were due to an improper econometric specification. They concluded that there is no residual adverse selection on risk type, once the information provided by risk classification has been taken into account.[41] This led to raise

[38] Insurance contracts are defined in terms of price *and* quantity, instead of price for any quantity. Insureds reveal their class by their choice in the menu of contracts. There is no "pooling" equilibrium, but a "separating" equilibrium.

[39] Stiglitz (1977) studied the monopolistic insurance case. Under asymmetric information, the monopolist insurer maximizes profit by supplying a menu of disciminating contracts. At the equilibrium situation, the high risks get some consumer surplus, but the low risks are restricted to partial insurance and do not get any surplus.

[40] See Crocker and Snow (1985) for a review of these models, and Dionne and Doherty (1992) for a early survey of adverse selection theory.

[41] On the other hand, Cohen (2005) finds some evidence of adverse selection for drivers with more than 3 years of driving experience.

fundamental questions about the proper tests for adverse selection (see Cohen and Siegelman 2010, for a complete review of empirical tests). More precisely, it seems that adverse selection plays a significant role in some insurance markets (annuities,[42] crop insurance[43]), but not in others (automobile, life insurance[44]), and that the evidence is mixed for still other markets (health[45]). This is due partly to the inability of individuals to use their information, or to their lack of informational advantage. This is also due to the difficulty to dissociate adverse selection from moral hazard in actual observations. Evidence of adverse selection requires that individuals with comprehensive insurance coverage report higher average claims than individuals with partial coverage, or uninsured individuals. But higher average claims for fully insured individuals may also be due to different *ex post* behavior, i.e., moral hazard. For this reason, a positive correlation between observed risk and insurance coverage does not necessarily signal the presence of adverse selection—although a negative correlation signals that adverse selection, as well as moral hazard, do not play a role. Moreover, as soon as empirical tests are considered, a simplifying assumption of the original Rothschild and Stiglitz (1976) model is enhanced: the model assumes identical individuals, except for their accident probability. In particular, they all have the same degree of risk aversion. Of course, in reality, attitudes toward risk differ. As the degree of risk aversion is one factor influencing the demand for insurance coverage, it becomes difficult to decide whether individuals who get more coverage from their insurers can be considered as "high risks" or not. It may also happen that they belong to the "good risk" group and demand more insurance simply because they are more risk averse. The problem gets worse if, as Einav and Finkelstein (2011, p. 124) remark, "in many instances individuals who value insurance more may also take action to lower their expected cost: drive more carefully, invest in preventive health care, and so on." Such a remark opens the door to the possibility of "advantageous selection": the insureds with high degree of coverage are those with the lowest accident probability. They demand more insurance, even at a high price, not because they are "high risks," but because they are on average more risk averse than the high risks, and the heterogeneity in risk aversion coefficients exceeds the heterogeneity in endowed riskiness.[46] Advantageous selection is not only a textbook curiosity. It has been documented recently in several markets, such as long-term care insurance (Finkelstein and McGarry 2006) and supplemental insurance (Fang et al. 2008). In these markets, the correlation between observed risk and insurance coverage is negative, instead of positive.

To overcome these pitfalls in testing for adverse selection, Einav et al. (2010) use identifying variations in the price of health insurance provided by one specific insurer to estimate the demand for insurance. The resulting variations in quantity, together with cost data, may then be used to estimate the marginal cost of additional policies. This information allows them to test for adverse selection (the marginal cost of contracts should be decreasing) and for the associated welfare loss. Their study provides evidence of adverse selection, but the welfare impact of this inefficiency seems to be small, in both absolute and relative terms.

When adverse selection is present, other insurance devices to deal with it are *experience rating* and *risk categorization*. They may be used as substitutes or complements to discriminating contracts. Dionne (1983) and Dionne and Lasserre (1985) on one hand, and Cooper and Hayes (1987) on the other hand, extended Stiglitz (1977) monopoly model to multi-period contracts, respectively with an

[42] See Finkelstein and Poterba (2002, 2004).

[43] See Makki and Somwaru (2001).

[44] See Cawley and Philipson (1999) and Hendel and Lizzeri (2003).

[45] See Cutler and Reber (1998) and Cardon and Hendel (2001).

[46] Advantageous selection can lead to too much insurance being purchased if there are transaction costs and competition among insurers drives profits to zero. In equilibrium, the marginal cost of insurance exceeds the market price (see Einav and Finkelstein 2011). The possibility of advantageous selection was first introduced by Hemenway (1990), who termed it "propitious" selection, and analyzed later on by De Meza and Webb (2001).

infinite horizon and a finite horizon, and with full commitment by the insurer to the terms of the contract.[47] Hosios and Peters (1989) extended the finite horizon case to limited commitment. In this case, contract renegociation becomes relevant, as information on the risk types increases over time. In addition, strategic use of accident underreporting becomes an issue.

Cooper and Hayes (1987) also extended the Rothschild and Stiglitz (1976) model to a two-period framework. They were able to demonstrate the beneficial effect of experience rating under full commitment by insurers, even when the insureds have the opportunity to switch to a different insurer in the second period (semi-commitment). At equilibrium, the competitive insurer earns a profit on good risks in the first period, compensated by a loss in the second period on those good risks who do not report an accident. This temporal profit pattern was labelled as "highballing" by D'Arcy and Doherty (1990). A different model, without any commitment, and assuming myopic behavior by insureds, was proposed by Kunreuther and Pauly (1985). The non-enforceability of contracts imply that sequences of one-period contracts are written. Private information by insurers about the accident experience of their customers allow negative expected profits in the first period and positive expected profits on the policies they renew in subsequent periods ("lowballing").[48] Later on, Dionne and Doherty (1994) proposed a model assuming private information by the insurer about the loss experience of their customer and "semi-commitment with renegociation": the insured has the option to renew his contract on prespecified conditions (future premiums are conditional on prior loss experience). This latter assumption seems to come closer to actual practices in insurance markets. They derive an equilibrium with first-period semipooling[49] and second-period separation. Their model predicts "highballing," since a positive rent must be paid in the second period to the high risk individuals who experienced no loss in the first period, and this is compensated by a positive expected profit on the pooling contract in the first period.[50] Their empirical test based on data from Californian automobile insurers provides some support to this prediction: they conclude that some (but not all) insurers use semi-commitment strategies to attract portfolio of predominantly low-risk drivers. In contrast, the prediction of "lowballing" had previously received empirical support in D'Arcy and Doherty (1990).

More recently, Crocker and Snow (2011) have brought the attention to the fact that multidimensional screening is routinely used by insurers to cope with adverse selection. With n mutually exclusive perils, insurers "can now exploit n signaling dimensions to screen insurance applicants" (p. 293). The "good risks" tend to accept higher deductibles for perils that they are less likely to be exposed to, for instance theft. This allows insurance markets to circumvent the nonexistence problem identified by Rothschild and Stiglitz. As the authors themselves remark, using multidimensional screening at a point in time presents an analogy with (and may be a substitute to) using repeated insurance contracts in a dynamic framework.[51]

Risk categorization, which uses statistical information on correlations between risk classes and observable variables (such as age, sex, and domicile), was first studied by Hoy (1982), Crocker and Snow (1986), and Rea (1992). Their work shows that risk categorization enhances efficiency when classification is costless, but its effect is ambiguous when statistical information is costly (see

[47] In the monopoly case, insureds cannot switch to an other insurer over time.

[48] In Kunreuther and Pauly (1985), the insurers have no information about the other contracts that their customers might write. For this reason, price–quantity contracts are unavailable. The equilibrium is a pooling equilibrium with partial insurance for the good risks, as in Pauly (1974).

[49] In the first period, insureds may choose either a pooling contract with partial coverage and possible renegociation in the second year, or the Rothschild–Stiglitz contract designed for high risks.

[50] For good risks who do not file a claim in the first period the reward takes the form of additional coverage in the second period.

[51] See also Bonato and Zweifel (2002) on the use of multiple risk to improve the assessment of loss probability.

also Bond and Crocker 1991). The latter result was recently challenged by Rothschild (2011) who shows that a ban on risk categorization is always suboptimal—even when categorization is costly. He introduces a distinction between a regime where categorization is *employed* by insurers (as in Crocker and Snow 1986) and a regime where categorization is *permitted*, but may or may not be employed in equilibrium. He then shows that a ban on risk categorization is always (whatever the insurance market regime) Pareto-dominated by having the government introduce a partial social insurance and simultaneously lifting the ban on risk categorization for private supplemental coverage. Quoting from Rothschild (2011, p. 269):

"The intuition behind the effectiveness of social insurance for preventing the negative consequences of lifting categorical pricing bans is simple. Categorical pricing bans are potentially desirable insofar as they implicitly transfer resources from individuals in low-risk categories to individuals in high-risk categories. (...) Providing partial social insurance effectively socializes the provision of this cross-subsidy. Lifting a categorical pricing ban then allows the market to employ categorical information to improve efficiency without risking undoing the cross-subsidy."

These results are of utmost political importance, given the ethical critics on the use of observable personal attributes, such as sex and race, in insurance rating. The problem of risk categorization is even more acute, when the personal attributes are not observable *a priori* but may be revealed to the insurer and/or the insured after some informational steps have been decided, as in the case of genetic diseases. Rothschild and Stiglitz (1997) point out that this results in a conflict between the social value of insurance and competition among insurers: if valuable information about the probability (or certainty) for the insured to suffer from a particular genetic disease can be made available, insurers will want to get this information. But this will result in less insurance coverage: the insureds who are virtually certain to get the disease will not be able to get insurance, whereas those who are revealed to be immune to the disease will not need insurance any longer.[52] For ethical reason, society prohibits the use of genetic information by insurers to categorize risks. But this means that adverse selection problems are enhanced, at least in medical insurance: as Doherty and Posey (1998) have shown, private testing is encouraged when test results are confidential and there is a treatment option available,[53] but the insurers are unable to charge different prices to different customers with private information about their genetic patrimony. Combining partial social insurance with supplemental private insurance, as suggested by Rothschild (2011), could be a way out of this conflict between the efficiency of insurance pricing and the mutuality principle.[54]

Like moral hazard, adverse selection is an important problem beyond the domain of insurance. It is mainly encountered in labor markets, where the employers are uninformed about the productivity of the prospective employees, and in financial markets, where banks and finance companies lack information on the reimbursement prospects of different borrowers. The insurance economics literature on adverse selection reviewed above has thus led to applications to other economic domains: see, e.g., Miyazaki (1977) for an application to the labor market and Stiglitz and Weiss (1981) for an application to credit markets. Note, however, that in these cases, quality signaling by the informed agents represents a feasible strategy to circumvent the asymmetric information problem (Spence 1973). For example, education and dividend payments find an additional justification in these

[52] This is an example of the well-known result that additional public information may have adverse welfare consequences (see, e.g., Arrow 1978).

[53] In contrast, Doherty and Thistle (1996) find that additional private information has no value if there is no treatment option conditional on this information.

[54] Note, however, that there exists alternative views on the welfare effect of asymmetric information. Using a two-period model where insureds have the option to switch insurers in the second period, de Garidel-Thoron (2005) shows that information sharing among insurers is welfare-decreasing. The reason is that this reduces the set of viable long-term contracts available to individuals in the first period competition game.

circumstances. In contrast, signaling does not generally occur in insurance markets: insureds do not engage in specific activities to signal that they are good risks.

1.4.3 Moral Hazard and Adverse Selection

Progress in analyzing moral hazard and adverse selection together has remained very limited. This was noted already by Arnott (1992) in the early 1990s and the situation has not changed significantly since then. This has for long limited the significance of empirical investigation in the economics of insurance, since both problems combine in actual insurance markets. A positive correlation between insurance indemnities and insurance coverage may be interpreted as signaling the presence of adverse selection, or moral hazard, or both. First attempts to address the two problems jointly were made by Dionne and Lasserre (1987) in the monopoly case and by Eisen (1990) in the competitive case, but did not find an echo in the literature. In the same period, Bond and Crocker (1991) pointed out that risk categorization may be endogenous if it is based on information on consumption goods that are statistically correlated with an individual's risk (*correlative products*). Thus, adverse selection and moral hazard becomes related. If individual consumption is not observable, taxation of correlative products by the government may be used to limit moral hazard and this would reduce the need for self-selection mechanisms as an instrument for dealing with adverse selection. However, this did not provide a general model.

Advances on this research front seem today more promising at the empirical level, using the materials provided by longitudinal data on insurance purchasing and loss experience. Adverse selection is due to differences in the dynamics of learning about the insured's true risk type for the insured himself and for the insurer. Once adverse selection has been identified (or not), using longitudinal data, the residual effect of moral hazard may be tested. This is the approach followed by Dionne et al. (2013) using data on automobile insurance and car accidents in France. They calibrate a simulation model for the optimal behavior of car owners, using the specific features of auto insurance in France and show that adverse selection and moral hazard should be expected. They then test for the presence of asymmetric learning on one hand and of moral hazard on the other hand. The results differ according to the experience of drivers. For drivers with less than 15 years of experience, they find strong evidence of moral hazard but little evidence of asymmetric learning. The latter occurs only for drivers with less than 5 years of experience. In contrast, for drivers with more than 15 years of experience, there is no evidence of moral hazard or adverse selection. These results are promising. It is likely that they will stimulate further research along the same line in other insurance contexts.

1.5 Developments: Insurance Market Structure

Numerous studies on the insurance sector have followed the lead provided by Joskow (1973). The availability of data and better incentives to perform economic research explain that most of these studies pertain to the US market.

– Insurance distribution systems were analyzed by several researchers, more particularly Cummins and VanDerhei (1979) and Berger et al. (1997).[55] In agreement with Joskow (1973), direct writing is generally found to be more cost efficient than independent agents. However, the differences in

[55] See also Zweifel and Ghermi (1990) for a study using Swiss data.

profit efficiency are not significant, which may be interpreted as an indication that independent agents provide valuable services. This interpretation has received support in several articles, e.g., Barrese et al. (1995) for the USA and Eckart and Räthke-Döppner (2010) for Germany. A comprehensive recent study on this topic is Cummins and Doherty (2006). The authors show that insurance intermediaries (brokers and independent agents) have a valuable role in improving the efficiency of the market. Over the past 20 years, insurance markets in several European and Asian countries have witnessed the marketing of insurance contracts through the banking channel—"bancassurance." The efficiency of this distribution system has been investigated in some recent studies, with mixed results so far: for instance, Chang et al. (2011) do not report efficiency gains for this system in Taiwan.

- Returns to scale in the insurance industry were submitted to empirical investigation by numerous authors in the 1980s, e.g., Doherty (1981) and Fecher et al. (1991). However, this question does not seem to have attracted much attention recently.
- The various forms of organizational structure in the insurance industry—stock companies, mutuals, Lloyds' underwriters—were analyzed in an agency theory framework by Mayers and Smith in a series of papers: (1981, 1986, 1988) among others. They verified that conflicts of interest between owners, managers, and policyholders affect the choice of organizational form for different insurance branches (see also Hansmann 1985; Cummins et al. 1999). Mutuals tend to prevail when the relationship between owners and policyholders triggers substantial agency costs. However, mutuals are constrained by their lack of access to external capital, with the result that mutuals with strong growth choose to convert to the stock structure when the constraint on their expansion becomes too costly: see also Mayers and Smith (2002) and Harrington and Niehaus (2002) for more recent references.
- Shim (2011) investigated the performance of property-liability insurers following mergers & acquisitions and diversification strategies. The results show that the performance of acquiring firms decreases during the gestation period after the M&As, and that more focused insurers outperform the product-diversified insurers.
- Following the lead provided by Joskow (1973), the effects of rate and solvency regulation were scrutinized in numerous researches, such as Borch (1974), Ippolito (1979), Munch and Smallwood (1980), Danzon (1983), Finsinger and Pauly (1984), Pauly et al. (1986), Harrington (1984, 1987), Cummins and Harrington (1987), D'Arcy (1988), Harrington and Danzon (1994), and Cummins et al. (2001). These studies were stimulated by the traditional government regulation of insurance activities, a general trend toward deregulation in the 1980s and 1990s,[56] and consumers' pressures for re-regulation (mainly in California and Florida) after major catastrophic events such as hurricane Andrew in 1992 and the Northridge earthquake in 1994. Dionne and Harrington (1992) concluded their survey of research on insurance regulation by noting: first, that "not much is presently known about the magnitude of the effects of regulatory monitoring and guaranty funds on default risk" (p. 32); and second, that rate regulation seems to have produced a variety of effects. It favored high risk groups, increased market size, and encouraged insurers' exits, but nonetheless reduced the ratio of premiums to losses and operating expenses. More recently, Klein et al. (2002) found that price regulation tends to increase leverage, while Doherty and Phillips (2002) remarked that, during the 1990s, with a trend toward deregulation, the role of rating agencies was enhanced: stringency in the rating procedures provided an incentive to decrease leverage and seemed to substitute for tight regulations. Rees et al. (1999), considering the focus of the European Commission on solvency regulation instead of rate regulation, suggest that "the

[56] Berry-Stölzle and Born (2012) provide an empirical account of the deregulation introduced in Germany in 1994. They find evidence of a significant price decrease in highly competitive lines, offset by higher prices in the other lines.

role of regulation in insurance markets should be confined to providing customers with information about the default risk of insurers" (p. 55).

Debates on insurance regulation were reinforced by the financial crisis in 2007–2008 and the doubts about insurers' solvency following the collapse of Lehman Brothers and the rescue of AIG by the federal government. Eling and Schmeiser (2010) derived ten consequences of the crisis for insurance supervision, while Lehmann and Hofmann (2010) stressed the differences between insurance and banking. Harrington (2009) reviewed the AIG case and questioned the exposure of the insurance sector to systemic risk. He noted that this sector remained largely on the periphery of the crisis, in contrast to AIG.[57] He also noted that the crisis revealed the imperfect nature of federal regulation of banks and related institutions. These considerations led him to reject the plans for creating a federal systemic risk regulator for insurers and other nonbank institutions designated as systemically significant. He also rejected the claim that the AIG crisis strengthens arguments for federal regulation of insurance, either optional or mandatory. In his view, "an overriding goal of any regulatory changes in response to the AIG anomaly should be to avoid further extension of explicit or implicit 'too big too fail' policies beyond banking" (p. 815). Notwithstanding these strong arguments against federal involvement in US insurance regulation, the debate goes on. In a recent comprehensive review of insurance regulation procedures, Klein (2012)—see also Klein and Wang (2009)—spells out the principles for insurance regulation and compares the traditional system of detailed state by state regulation still in force in the USA with the principles-based approach currently introduced in the EU member countries under Solvency II.[58] He concludes that, compared to the latter European developments, "the systems for solvency and market conduct regulation in the United States warrant significant improvement," and that "the (US) states should move forward with full deregulation of insurance prices" (p. 175).

– A related avenue of research, not considered by Joskow (1973), deals with cycles in the insurance industry. It has been noticed in the 1970s that insurance company profits seem to be submitted to more or less regular cycles, and that this phenomenon is reflected in cyclical capacity and premium rates. The Geneva Association sponsored one of the first investigations in this area (Mormino 1979). The most often quoted papers were published a few years later by Venezian (1985), Cummins and Outreville (1987), and Doherty and Kang (1988). As pointed out by Weiss (2007, p. 31), "in tracking underwriting cycles, most of the attention tends to be directed at insurance pricing, or, conversely, insurance underwriting profits, rather than the amount of coverage available." The US insurance liability "crisis" of the mid-1980s and the over-capitalization of property-liability insurers during the 1990s stimulated research on insurance cycles (see Harrington 1988; Cummins and Doherty 2002). Haley (1993) and Grace and Hotchkiss (1995) document an impact of external factors—mainly interest rates—on underwriting profits, but the latter authors find that external unanticipated real economic shocks have little effect on underwriting performance. Other research suggests that delays in the adjustment of premiums to expected claims costs, due to regulation or structural causes, external shocks to supply capacity and variations in insurer insolvency risk are responsible for cyclical effects: see Winter (1994), Gron (1994), Cagle and Harrington (1995), Doherty and Garven (1995), and Cummins and Danzon (1997). More recently, Choi et al. (2002) compare six alternative insurance pricing models as theories of the underwriting cycle. They show that two models are consistent with short run and long run data on underwriting profits: the capacity constraint model and the actuarial pricing model. Cummins and Nini (2002) provide empirical evidence that the over-capitalization of property-liability insurers during the 1990s was mainly due

[57] AIG failure is mainly attributed to two causes. First, a subsidiary of AIG—AIG Financial Products—became heavily involved in the writing of credit default swaps (CDS). Second, an other subsidiary, operating in the life branch, had engaged in securities lending programs that were severely hurt by the outburst of the subprime crisis. In either case, insurance operations were not concerned.

[58] The Solvency II regulation is presented and analyzed in Eling et al. (2007).

to capital gains during the stock market boom and to retained earnings. They interpret their results as providing evidence that insurers tend to hoard capital in favorable periods as a hedge against adverse shocks in the future. This behavior affects negatively underwriting profits and is a source of cycles in profitability.

Following the lead provided by Cummins and Outreville (1987), research on insurance cycles has also been conducted at the international level, and provided evidence that these cycles are not specific to the US market: see Lamm-Tennant and Weiss (1997), Chen et al. (1999), Leng and Meier (2006), and Meier and Outreville (2006).

– The economic analysis of practical problems that the insurance industry has been facing over the past years also attracted the attention of researchers. One of these problems, the insurance of catastrophes, has become a major concern for the industry and the subject of intensive academic research. Beyond the insurance industry, catastrophes have become an issue for the economy at large. Events like Hurricane Katrina on the Gulf Coast in 2005 or the Fukushima catastrophe in Japan in 2011 with its sequence of "earthquake-tsunami-major nuclear accident" had repercussions for the international economy and not only on the local scene. Given the resurgence of major catastrophic events every year somewhere in a globalized world, it has become unappropriate to continue to define catastrophes as "Low- probability/High-consequences events" (see Kunreuther and Michel-Kerjan 2009, p. 351). The major journals in the economics of insurance and some general economics journals devoted special issues to this topic over the past two decades. Books and contributed volumes have also addressed this issue.[59] Researchers have tended to take a broad view of the subject, so that the term "catastrophe" has been used to encompass different kinds of situations: not only natural catastrophes (like earthquakes, tsunamis, floods, and hurricanes) and man-made catastrophes (such as Tchernobyl or Bhopal); but also socioeconomic developments that result in catastrophic accumulation of claims to insurers (see, e.g., Zeckhauser 1995). The prominent example is the liability crisis in the USA, due to the adoption of strict producers' liability and the evolution in the courts' assessments of compensations to victims, as in the cases of asbestos, breast implants, pharmaceuticals, etc. (see Viscusi 1995). To cope with the financial consequences of catastrophes, traditional insurance and reinsurance are often considered as insufficient (see Kunreuther 1996; Froot 1999; Cummins et al. 2002). Some researchers invoke difficulties individuals would have in dealing with low-probability/high-loss events (Kunreuther and Pauly 2004). Others invoke capital market imperfections and market failure in reinsurance supply (Froot 2001; Zanjani 2002; Froot and O'Connell 2008). Still others point to US insurance price regulation in catastrophe-prone lines of business as a major source of inefficiency in insurance and reinsurance markets (Cummins 2007). Several researchers have advocated more government involvement (see, e.g., Lewis and Murdock 1996; Kunreuther and Pauly 2006),[60] but others argue that the government has no comparative advantage to the market in providing coverage for catastrophic losses (Priest 1996) and call instead for less government intervention by deregulating insurance prices (Cummins 2007). Alternative solutions may be found in financial innovation, either in the design of insurance contracts, by introducing a decomposition of insurance risk into a systemic and a diversifiable component (see Doherty and Dionne 1993; Schlesinger 1999; Doherty and Schlesinger 2002), or in the design of new financial securities (see Sect. 1.6 below), or both.
– At the other end of the insurability spectrum, microinsurance emerged as a new topic for research in insurance economics. The fact that a large fraction of the world population has no access to the benefits of insurance coverage stimulated practical initiatives to remedy this situation and interest among researchers and international organizations—the ILO (International Labour Office) for

[59] See, in particular, Froot (1999), OECD (2005), Wharton Risk Management Center (2007), Kunreuther and Michel-Kerjan (2009), as well as Courbage and Stahel (2012).

[60] Monti (2011) provides a recent review of public-private arrangements already existing in the OECD area.

example. A recent study (Biener and Eling 2012) reviews the current situation of microinsurance. The authors point out that the microinsurance industry has experienced strong growth in the recent years (10 % on average), but that much remains to be done and that further developments are constrained by well-known insurability problems: risk assessment, asymmetrical information, and lack of financial resources in the uninsured population. They also provide tentative solutions to overcome these problems.

– Corporate governance issues in the insurance industry have attracted more attention from researchers in the wake of the 2008 financial crisis and the collapse of AIG. The impact of corporate governance and institutional ownership on efficiency (Huang et al. 2011), risk-taking (Cheng et al. 2011), mergers and acquisitions (Boubakri et al. 2008), and CEO turnover (He and Sommer 2011), among other issues, were recently investigated.[61]
– Let us mention, finally, a topic which was not covered by Joskow (1973) and which does not seem to have concerned many researchers: the issues raised by international insurance trade. Research on this topic remained relatively limited and concentrated in Europe: see Dickinson (1977) for an early reference, Pita Barros (1993) for additional analysis, and Arkell (2011) for a recent report stressing the essential role of insurance services for trade growth and development.

1.6 New Approaches: Finance and Insurance

Apart from the tremendous developments summarized in the three preceding sections, risk and insurance economics has witnessed a major reorientation in the 1970s and 1980s: insurance has been analyzed more and more in the general framework of financial theory. This change of perspective was implicit in the definition of Arrow (1970): "insurance is an exchange of money for money." It was also foreshadowed by the recognition that insurers were financial intermediaries (Gurley and Shaw 1960). It became soon impossible to maintain a dichotomy in the analysis of the insurance firm: insurance operations on one hand, financial investment on the other hand. As a result, insurance research became deeply influenced by advances in the theory of finance. The more so that finance underwent a major revolution in the 1970s, with the development of option theory, and that this revolution stressed the similarity between insurance products and new concepts due to financial innovation (e.g., *portfolio insurance*).[62]

1.6.1 Portfolio Theory and the CAPM

The influence of portfolio theory on the analysis of insurance demand was mentioned in Sect. 1.3. But this theory had also a profound influence on the theory of insurance supply. It was soon recognized that financial intermediaries could be analyzed as a joint portfolio of assets and liabilities (Michaelson and Goshay 1967), and this global approach was applied to insurance company management. Under this view, insurers have to manage a portfolio of correlated insurance liabilities and investment assets, taking into account balance sheet and solvency constraints, and there is no justification for separating the operations in two distinct domains: what matters is the overall return on equity (see Kahane and Nye 1975; Kahane 1977).[63]

[61] See Boubakri (2011) and the September 2011 Special Issue of *The Journal of Risk and Insurance* for a recent survey of corporate governance in the insurance industry.

[62] The similarity between option contracts and insurance policies was stressed by Briys and Loubergé (1983).

[63] See also Loubergé (1983) for an application to international reinsurance operations, taking foreign exchange risk into account, and MacMinn and Witt (1987) for a related model.

This way of looking at insurance operations led to a theory of insurance rating, reflecting the move observed a decade earlier in finance from portfolio theory to the capital asset pricing model. Applying this model to insurance, it turns out that equilibrium insurance prices will reflect the undiversifiable risk of insurance operations. If insurance risks are statistically uncorrelated with financial market risk, equilibrium insurance prices are given by the present value of expected claims costs (in the absence of transaction costs). If they are statistically correlated, a positive *or negative* loading is observed in equilibrium. The model was developed by Biger and Kahane (1978), Hill (1979), and Fairley (1979). It was empirically evaluated by Cummins and Harrington (1985). It was also applied to determine the "fair" regulation of insurance rating in Massachussets (Hill and Modigliani 1986).[64]

1.6.2 Option Pricing Theory

A main limitation of the capital asset pricing model is that it does not take into account nonlinearities arising from features such as limited liability and asymmetric tax schedules. These aspects are best analyzed using option pricing theory, since it is well known that optional clauses imply nonlinearities in portfolio returns. Doherty and Garven (1986) and Cummins (1988) analyzed the influence of limited liability and default risk on insurance prices, while Garven and Loubergé (1996) studied the effects of asymmetric taxes on equilibrium insurance prices and reinsurance trade among risk-neutral insurers. A major implication of these studies is that loaded premiums are not only the reflect of transaction costs and asymmetric information, or insurers' risk aversion. They reflect undiversifiable risk arising from institutional features, and they lead to prices implying risk-sharing in equilibrium, even when market participants are risk neutral.

The importance of option theory for the economics of insurance has also been recently observed in the domain of life insurance. This resulted from the fact that competition between insurers and bankers, to attract saving, has led to the inclusion of numerous optional features (hidden options) in life insurance contracts. Advances in option theory have thus been often used to value life insurance contracts (see, e.g., Brennan and Schwartz 1976; Ekern and Persson 1996; Nielsen and Sandmann 1996), or to assess the effects of life insurance regulation (Briys and de Varenne 1994).

1.6.3 Insurance and Corporate Finance

The portfolio approach to insurance demand led to a paradox when applied to corporations. The latter are owned by stockholders who are able to diversify risks in a stock portfolio. If insurance risks, such as accident and fire, are diversifiable in the economy, the approach leads to the conclusion that corporations should not bother to insure them. They would increase shareholders' wealth by remaining uninsured instead of paying loaded premiums (Mayers and Smith 1982).[65] The paradox was solved using the modern theory of corporate finance, where the firm is considered as a nexus of contracts between various stakeholders: managers, employees, suppliers, bondholders, banks, stockholders,

[64] Myers and Cohn (1986) extended the model to multi-period cash flows, while Kraus and Ross (1982) considered the application to insurance of the more general arbitrage pricing theory.

[65] The same kind of argument was used by Doherty and Tinic (1981) to question the motivation of reinsurance demand by insurers.

consumers, etc. Reduction of contracting and bankruptcy costs provides an incentive to manage risk and to purchase insurance, even if the premium is loaded and shareholders are indifferent to insurance risk: see Main (1982), Mayers and Smith (1982, 1990), and Stulz (1984). In addition, increasing marginal cost of external financing and convex tax schedules arising from progressive tax rates and incomplete loss offset offer other explanations for concern with insurance risk management in widely held corporations: see Froot et al. (1993), Smith and Stulz (1985), and Smith et al. (1990).

These considerations have changed the relationship of corporate managers to risk management in general and insurance in particular. These tools are no longer used simply because risks arise. They must find a justification in the overall firm objective of value maximization. Following these premises, several studies addressed the relationship between corporate risk management and the capital structure decision or the dividend policy. For instance, Auñon-Nerin and Ehling (2008) find that higher leverage increases the demand for corporate insurance and the use of derivatives, while hedging has in general a significant positive effect on leverage (see also Zou and Adams 2008). This is in accordance with corporate concern for bankruptcy and agency costs. They also find that corporate hedging is negatively related to the dividend payout ratio. This is related to the use of cash flows as a possible substitute for insurance (on this aspect see also Rochet and Villeneuve 2011).[66] In addition, as Doherty (1997) noted, the development of financial engineering in the 1980s challenged traditional insurance strategies in corporate risk management. Traditional insurance strategies often involve large transaction costs, and they fail if the risk is not diversifiable, as in the case of the US liability crisis. For this reason, innovative financial procedures, such as finite risk plans and financial reinsurance, represent alternative instruments for dealing with corporate risks. Of course, they widen the competitive interface between banks and insurers.

The theory of corporate finance was also used by Garven (1987) to study the capital structure decision of the insurance firm. His paper shows that redundant tax shields, default risk, bankruptcy costs, and the above-mentioned agency costs influence the insurer's capital structure decision. More recently, Plantin (2006) has emphasized that reinsurance purchases and capital structure decisions are linked. Professional reinsurers are used by insurers as a signal of credible monitoring sent to the financial market. Reinsurance is not only used as a device to mutualize risks, as in Borch (1962), or to address agency problems, as in Mayers and Smith (1990). It is also used as a complement in the insurer's capital structure strategy.

At the empirical level, Garven and Lamm-Tenant (2003), as well as Powell and Sommer (2007), provided evidence that reinsurance purchases are positively related to insurer leverage. More recently, Shiu (2011) has used data from the UK non-life insurance industry to test the two-way relationship between reinsurance and insurers' capital structure. His results show that leverage exerts a positive influence on reinsurance purchases and that higher leverage is associated with more reinsurance purchases. However, he also finds that the use of financial derivatives by insurers has a moderating impact on this two-way relationship.

Taking a more general view, Hoyt and Liebenberg (2011) have investigated whether an integrated risk management approach—as defined by Meulbroek (2002)—has a positive influence on insurers' value. They use Tobin's Q as a measure of firm value and a maximum-likelihood procedure to estimate joint equations for the determinants of an integrated risk management policy and its impact on Q for a sample of 117 publicly traded US insurers.[67] They find that insurers engaged in integrated risk

[66] Rochet and Villeneuve (2011) show that cash-poor firms should hedge using financial derivatives but not insure, whereas the opposite is true for cash-rich firms.

[67] Tobin's Q is defined in this case as the market value of equity plus the book value of liabilities divided by the book value of assets.

management "are valued roughly 20 percent higher than other insurers after controlling for other value determinants and potential endogeneity bias" (p. 810). They also find that those insurers are larger, with less leverage, and relying less on reinsurance than other insurers.

This latter result, added to those obtained above by Shiu (2011), can be related to earlier considerations by Doherty (1997) that insurers' management has been deeply influenced by developments in the financial markets. The concept of asset-liability management, which has its roots in the portfolio approach mentioned above, means that insurers are less relying on reinsurance as the natural instrument to hedge their risks and send signals to their partners. Indeed, developments in the financial markets over the past 20 years have seen the emergence of derivative products intended to complement traditional reinsurance treaties in an integrated risk management view.

1.6.4 Insurance and Financial Markets

In 1973, the insurance/banking interface was a sensitive subject. It was generally not well considered, in the insurance industry, to state that insurance was a financial claim and that insurers and bankers performed related functions in the economy. Some 40 years later, and after numerous experiences of mergers and agreements between banks and insurers, the question is not whether the two activities are closely related,[68] but where do they differ.[69]

It is easy for an economist of risk and insurance to provide a general answer to this question. The answer is founded on Borch's mutuality principle (see Sect. 1.2) and on subsequent work on risk-sharing. Insurance and banking, like all financial activities, are concerned with the transfer of money across the two-dimensional space of time and states of nature. Insurance deals mainly—but not exclusively (see life insurance)—with transfers across states that do not necessarily involve a change in social wealth. In contrast, banking and financial markets perform transfers across states which often involve a change in social wealth. In other words, insurance is mainly concerned with diversifiable risk; banks and finance companies (such as mutual funds and hedge funds) are mainly concerned with undiversifiable (social) risk.

This kind of distinction has been used before to draw a line between private and public (social) insurance. According to this view, social insurance is called for when the limits of private insurability are reached in the sense that the insured events are not independent, so that diversifiability does not obtain: epidemic diseases, losses from natural catastrophes, unemployment, etc.[70] But, social insurance is limited by national frontiers, and in the absence of redistributive concerns, or of market incompleteness due to moral hazard, it has become more and more obvious that financial markets are able to perform some social insurance functions, in addition to their traditional function of sharing production risk.

A case in point is the evolution in the natural catastrophes branch of insurance. As a matter of fact, since losses from natural catastrophes are correlated, they should be excluded from the private insurance area. Nonetheless, private insurance companies used to cover this risk because geographical dispersion seemed possible using the international reinsurance market. However, over the last two decades, the private insurability of this risk has been challenged by various developments: an increased

[68] The convergence between reinsurance and investment banking was emphasized by Cummins (2005).

[69] The debate has regained importance after the 2008 financial market crisis and the collapse of AIG. Large insurance companies have been ranked with banks in the group of "Systemic Important Financial Institutions" (SIFI) and are threatened to be subject to the same regulations as banks. This is an occasion for the insurance industry to underline the differences between banking and insurance (see Lehmann and Hofmann 2010; Geneva Association 2010).

[70] Public insurance may also be justified on equity considerations, e.g., in medical insurance.

frequency of hurricanes, huge losses, and a concentration of insured values in selected exposed areas of the globe: the USA (mainly California and Florida), Japan, and Western Europe (mainly the South). As a result, potential losses have exceeded the financial capacity of the catastrophe reinsurance market (see Kielholz and Durrer 1997; Cummins et al. 2002).

One possible solution to the insurability problem is the traditional recourse to government insurance using increased taxation, i.e., social insurance. This is the solution which was adopted in France (Magnan 1995) and in some other countries[71]: a reserve fund financed by specific taxes on property-liability insurance contracts indemnifies victims from natural catastrophes. The viability of this solution is however endangered in the long run by increasing risk due to wrong incentives (development of activities and constructions in areas exposed to cat risk), and by pressure on the government to enlarge the scope of coverage while maintaining low rates.

A second solution is the transfer of the risk using special purpose derivative markets. This was the solution proposed by the Chicago Board of Trade (CBOT) with the catastrophe options and futures contracts launched in December 1992: see D'Arcy and France (1992), Cummins and Geman (1995), and Aase (1999) for an analysis of these contracts.[72] However, the CBOT contracts were withdrawn after some years due to lack of success.[73] Following Hurricane Katrina in 2005, new contracts of the same type were nevertheless launched in 2007 by the Chicago Mercantile Exchange (CME) and the Insurance Futures Exchange (IFEX). A main difference with the earlier CBOT contracts is their focus on US hurricanes and US tropical wind. However, given the experience with the CBOT contracts, experts have doubts about the ultimate success of this new venture (see Cummins 2012).

A third solution is the securitization of the risk using more familiar securities, such as coupon bonds, issued by a special purpose company (on behalf of an insurer, a reinsurer or a non financial company), or by a public agency (on behalf of the State): see Litzenberger et al. (1996) and Loubergé et al. (1999) for early presentations and analysis of insurance-linked bonds (widely known as "Cat Bonds"). In a cat bond arrangement, a special-purpose reinsurer (SPR) issues a coupon bond on behalf of the sponsoring entity and improves the return on the bonds with a premium paid by the sponsor. The principal is then invested into first-class securities, such as government bonds. However, on the investor side, the principal and the coupons are at risk, in the sense that they may be lost, partially or even totally, if a catastrophe occurs and the cat bond is triggered. In this case, the proceeds of the investment is used by the SPR to pay indemnities to the sponsor. The catastrophic risk has been transferred to the financial market using familiar securities as transfer vehicle. In contrast to CBOT derivatives, these insurance-linked securities were well received by the market. Their success has been based on the huge pool of financial capacity provided by worldwide capital markets and the prospects for risk diversification made available to investors: catastrophic insurance losses are, in principle, uncorrelated with financial market returns. In addition, cat bonds that have been based on an index of losses due to a specific catastrophic event, or triggered by such a specific event

[71] In the USA, where a National Flood Insurance program already exists for long, and where California has established a government earthquake insurance program (the California Earthquake Authority), the possible creation of state or regional catastrophe funds is being hotly debated, given the unconvincing example of the two above-mentioned programs (see Klein and Wang 2009).

[72] The early options and futures on four narrow-based indices of natural catastrophes were replaced in October 1995 by call spreads on nine broad-based indices. Lewis and Murdock (1996) proposed to have the same kind of contract supplied by Federal authorities, in order to complete the reinsurance market.

[73] Harrington and Niehaus (1999) had reached the conclusion that basis risk would not be a significant problem for PCS derivative contracts, but later on Cummins et al. (2004) reached a different conclusion: they attibute the lack of success to basis risk. One may add that, possibly, the failure was due to the absence of arbitrage trading. Arbitrage trading between a derivative market and the market for the underlying instrument is essential to the provision of liquidity in derivatives trading for hedging and speculation purposes. However, in the case of PCS option contracts such trading was impossible. The only market for the trading of insurance portfolios is the reinsurance market, not liquid enough to be used as a vehicle in arbitrage trading.

(parametric trigger), have allowed to avoid the moral hazard arising from products based on the record of losses experienced by the sponsor.[74] On the supply side, cat bonds provide sponsors with coverage that extends over several years, at fixed terms (unlike reinsurance contracts), and that is free from default risk since the proceeds from the bond issue are fully collateralized using highly rated securities.[75] Cat bonds have attracted a wide interest among insurance practitioners (see Swiss Re 2009)[76] and academic researchers (see Barrieu and Karoui 2002; Lee and Yu 2002; Nell and Richter 2004; Cummins 2008; Michel-Kerjan and Morlaye 2008; Barrieu and Loubergé 2009; Finken and Laux 2009).[77] The development of the market for these securities indicates that they filled a gap in the reinsurance market, although the success has not been as huge as initially anticipated: cat bond issues started with a few issues prior to 2000, then the market peaked with 27 issues in 2007, and regained momentum in 2010 (22 issues) after a drop to 13 issues in 2008, due to the financial crisis. The market is nevertheless developing over time, with positive and negative shocks provoked by natural catastrophes and financial crises: see Cummins (2012) for a comprehensive report on the state of the market at year-end 2011.

A fourth solution available to an insurer to hedge catastrophic risk outside of the reinsurance market is provided by *Catastrophic Equity Puts* (Cat-E-Puts). Under this arrangement, the insurer or reinsurer purchases from the option writer the right to issue preferred stocks at a specific price following the occurence of a catastrophe. This allows the insurer to take advantage of fresh funding at a predetermined cost in a situation where recourse to the capital market would be prohibitive for him. It illustrates the increased integration of insurance and investment banking, both activities performing a fundamental economic function, the transfer of risks.[78]

1.7 Conclusion

In the early 1970s, it was not clear what would be the development of risk and insurance economics over the years to come. Some 40 years later, it is comforting to realize that considerable developments have taken place: the length of the reference list below, unconventionally divided in pre-1973 and post-1973 references gives an account of the quantitative aspects of these developments.

As this chapter shows, the developments have mainly taken place along three avenues of research:

1. The theory of risk-taking behavior in the presence of multiple risks, which encompasses the theory of optimal insurance coverage, the theory of optimal portfolio investment, and the theory of optimal risk prevention.

[74] Exposure to moral hazard for the investor is traded against basis risk for the sponsor.

[75] The risk of default by the reinsurance provider is a concern in the high-layer segment of the reinsurance market.

[76] Still, it remains that the use of insurance-linked securities raises sensitive issues in terms of regulation. Not because these instruments would represent a danger for the stability of the financial system, but because regulators, more particularly in the USA, are reluctant to consider them as genuine alternative mechanisms for risk transfer: see Klein and Wang (2009).

[77] The success with cat bonds stimulated interest for other insurance-linked securities, particularly in the life insurance sector (mortality bonds, longevity bonds): see Cowley and Cummins (2005), Lin and Cox (2005), Albertini and Barrieu (2009), Cummins and Weiss (2009), and Chen and Cox (2009).

[78] Other innovations, such as *sidecars* and *ILWs* (Industry Loss Warranties), are different in nature from those presented in this section. They represent innovations that improve the capacity of the reinsurance market, without introducing an alternative or complement to reinsurance contracts.

2. The issues raised by asymmetric information for contracts design and market equilibrium, a theme which extends beyond insurance economics and concerns all contractual relations in the economy, e.g., on labor markets, products markets, and financial markets.
3. The applications of new financial paradigms, such as contingent claims analysis, to the analysis of insurance firms, insurance markets and corporate risk management, a development which links more closely insurance economics to financial economics, and insurance to finance.

Risk and insurance economics represents nowadays a major theme in general economic theory. This does not mean that risk and insurance education, per se, has become a predominant theme—although important developments took place also at this level. But risk and insurance issues have become pervasive in economic education, more particularly in microeconomics. To support this statement, one may verify in the second section of the following list of references that many important papers for the advancement of risk and insurance theory were published in general economic and financial journals, and not only in the leading specialized reviews. Indeed, given that this goal of the 1970s was reached, it may be wondered whether an other objective, the development of specialized risk and insurance education and research, which had been given less importance then, should not be reevaluated today. From the experience with the tremendous research activity we have witnessed in the study of financial markets over the past years, we are allowed to infer that specialized research in insurance economics would receive a major impulse from the creation of complete, reliable, and easily accessible insurance databases. True, compared with the situation at the end of the 1990s, the last 12 years have been characterized by a breakthrough of empirical research on insurance themes, most notably in the asymmetric information area where the implications of models have been subject to empirical tests. These tests represent a fundamental progress in the economics of risk and insurance. They provide results that enhance our understanding of insurance markets and the authors must be congratulated for their efforts. But they are still too often based on proprietary data, made available on a case by case basis, not on widely available insurance data bases. The availability of such data bases would certainly trigger more interest for dissertations on risk and insurance themes among beginning doctoral students in economics.

References

1. Publication until 1973

Akerlof GA (1970) The market for 'lemons': quality uncertainty and the market mechanism. Q J Econ 84: 488–500

Arrow KJ (1963a) Uncertainty and the welfare economics of medical care. Am Econ Rev 53:941–969

Arrow KJ (1963b) Liquidity preference. In: Arrow KJ (ed) The economics of uncertainty, vol 285. Lecture Notes for Economics, Stanford University, pp 33–53

Arrow KJ (1953) "Le rôle des valeurs boursières pour la répartition la meilleure des risques," in Econométrie, CNRS, Paris, 41–47. English version: "The role of securities in the optimal allocation of risk-bearing," Rev Econ Stud, 1964, 31:91–96

Arrow KJ (1970) Insurance, risk and resource allocation. In: Arrow KJ (ed) Essays in the theory of risk bearing. North Holland, p 134–143

Borch K (1960) The safety loading of reinsurance premiums. Skandinavisk Aktuarie-tidskrift 43:163–184

Borch K (1962) Equilibrium in a reinsurance market. Econometrica 30:424–444

Carter RL (1972) Economics and insurance PH Press

Debreu G (1959) Theory of value Wiley

Ehrlich J, Becker G, (1972) Market insurance, self insurance and self protection. J Polit Econ 80:623–648

Friedman M, Savage LJ, (1948) The utility analysis of choices involving risk. J Polit Econ 56:279–304

Gould JP (1969) The expected utility hypothesis and the selection of optimal deductibles for a given insurance policy. J Bus 42:143–151

Greene M (1971) Risk aversion, insurance and the future. Indiana University Press

Greene M (1973) Risk and insurance. South Western

Gurley J, Shaw ES, (1960) Money in a theory of finance. Brookings Institution
Hammond JD (1968) Essays in the theory of risk and insurance. Scott Foresman Huebner Foundation for Insurance Education (1972) Risk and insurance instruction in American colleges and universities. University of Pennsylvania
Joskow PJ (1973) Cartels, competition and regulation in the property-liability insurance industry. Bell J Econ Manag Sci 4:327–427
Kihlstrom RE, Pauly M, (1971) The role of insurance in the allocation of risk. Am Econ Rev 61:371–379
Lintner J (1965) Security prices, risk and maximal gain from deiversification. J Finan 20:587–615
Mahr W (1964) Einführung in die Versicherungswirtschaft. Duncker & Humblot
Markowitz HM (1959) Portfolio selection—efficient diversification of investments. Wiley
Mehr R, Hedges B, (1963) Risk management in the business enterprise. Irwin
Michaelson JB, Goshay RC, (1967) Portfolio selection in financial intermediaries: a new approach. J Finan Quant Anal 2:166–199
Mossin J (1966) Equilibrium in a capital asset market. Econometrica 34:768–783
Mossin J (1968) Aspects of rational insurance purchasing. J Polit Econ 79:553–568
von Neumann J, Morgenstern O, (1947) Theory of games and economic behavior. Princeton University Press
Pashigian B, Schkade L, Menefee G (1966) The selection of an optimal deductible for a given insurance policy. J Bus 39:35–44
Pauly M (1968) The economics of moral hazard: comment. Am Econ Rev 58:531–536
Pfeffer I (1956) Insurance and economic theory. Irwin
Pratt J (1964) Risk aversion in the small and in the large. Econometrica 32:122–136
Ross S (1973) The economic theory of agency: the principal's problem. Am Econ Rev 63:134–139
Rothschild M, Stiglitz J, (1970) Increasing risk: I. A definition. J Econ Theory 2:225–243
Savage LJ (1954) Foundation of statistics. Wiley
Sharpe W (1964) Capital asset prices: a theory of market equilibrium under conditions of risk. J Finan 19: 425–442
Smith V (1968) Optimal insurance coverage. J Polit Econ 79:68–77
Spence M, Zeckhauser R, (1971) Insurance, information and individual action. Am Econ Rev 61:380–387
Spence M (1973) Job market signalling. Q J Econ 87:355–374
Wilson R (1968) The theory of syndicates. Econometrica 36:113–132

2. Publication after 1973

Aase K (1999) An equilibrium model of catastrophe insurance futures and spreads. Gen Papers Risk Insur Theory 24:69–96
Abbring J, Chiappori PA, Pinquet J (2003) Moral hazard and dynamic insurance data. J Eur Econ Assoc 1: 767–820
Albertini L, Barrieu P, (2009) The handbook of insurance-linked securities. Wiley, New York
Allard M, Cresta JP, Rochet JC (1997) Pooling and separating equilibria in insurance markets with adverse selection and distribution costs. Gen Papers Risk Insur Theory 22:103–120
Allen F (1985) Repeated principal-agent relationships with lending and borrowing. Econ Lett 17:27–31
Arkell J (2011) The essential role of insurance services for trade growth and development. Geneva Association
Arnott R (1992) Moral hazard and competitive insurance markets. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 325–358
Arnott R, Stiglitz JE, (1990) The welfare economics of moral hazard. In: Loubergé H (ed) Risk, information and insurance: essays in the memory of Karl Borch. Kluwer Academic Publishers, p 91–121
Arrow KJ (1974) Optimal insurance and generalized deductibles. Scand Actuar J 1:1–42
Arrow KJ (1978) Risk allocation and information: some recent theoretical developments. Gen Papers Risk Insur 8:5–19
Auñon-Nerin D, Ehling P (2008) Why firms purchase property insurance. J Finan Econ 90:298–312
Barrese J, Doerpinghaus H, Nelson J (1995) Do independent agent insurers provide superior service? The insurance marketing puzzle. J Risk Insur 62:297–308
Barrieu P, El Karoui N (2002) Reinsuring climatic risk using optimally designed weather bonds. Gen Papers Risk Insur Theory 27:87–113
Barrieu P, Loubergé H (2009) Hybrid cat bonds. J Risk Insur 76:547–578
Berger A, Cummins D, Weiss M (1997) The coexistence of multiple distribution systems for financial services: the case of property-liability insurance. J Bus 70:515–546
Berry-Stölzle T, Born P (2012) The effect of regulation on insurance pricing: the case of Germany. J Risk Insur 79:129–164
Biener C, Eling M, (2012) Insurability in microinsurance markets: an analysis of problems and potential solutions. Gen Papers Risk Insur Issues Pract 37:77–107
Biger N, Kahane Y, (1978) Risk considerations in insurance ratemaking. J Risk Insur 45:121–132
Bond EW, Crocker KJ, (1991) Smoking, skydiving and knitting: the endogenous categorization of risks in insurance markets with asymmetric information. J Polit Econ 99:177–200

Bonato D, Zweifel P, (2002) Information about multiple risks: the case of building and content insurance. J Risk Insur 69:469–487
Bond EW, Crocker KJ, (1997) Hardball and the soft touch: the economics of optimal insurance contracts with costly state verification and endogenous monitoring costs. J Public Econ 63:239–264
Borch K (1974) Capital markets and the supervision of insurance companies. J Risk Insur 41:397–405
Boubakri N (2011) Corporate governance and issues from the insurance industry. J Risk Insur 78:501–518
Boubakri N, Dionne G, Triki T (2008) Consolidation and value creation in the insurance industry: the role of governance. J Bank Finan 32:56–68
Boyer M, Dionne G (1989a) An empirical analysis of moral hazard and experience rating. Rev Econo Stat 71:128–134
Boyer M, Dionne G (1989b) More on insurance, protection and risk. Can J Econ 22:202–205
Brennan MJ, Schwartz E, (1976) The pricing of equity-linked life insurance policies with an asset value guarantee. J Finan Econ 3:195–213
Briys E (1988) On the theory of rational insurance purchasing in a continuous time model. Gen Papers Risk Insur 13:165–177
Briys E, Dionne G, Eeckhoudt L (1989) More on insurance as a Giffen good. J Risk Uncertainty 2:420–425
Briys E, Kahane Y, Kroll Y (1988) Voluntary insurance coverage, compulsory insurance, and risky-riskless portfolio opportunities. J Risk Insur 55:713–722
Briys E, Loubergé H (1983) Le contrat d'assurance comme option de vente. Finance 4:139–153
Briys E, Loubergé H (1985) On the theory of rational insurance purchasing. J Finan 40:577–581
Briys E, Schlesinger H, (1990) Risk aversion and the propensities for self-insurance and self-protection. South Econ J 57:458–467
Briys E, Schlesinger H, von Schulenburg M (1991) Reliability of risk management: market insurance, self-insurance and self-protection reconsidered. Gen Papers Risk Insur Theory 16:45
Briys E, de Varenne F (1994) Life insurance in a contingent claims framework: pricing and regulatory implications. Gen Papers Risk Insur Theory 19:53–72
Caballé J, Pomansky A (1996) Mixed risk aversion. J Econ Theory 71:485–513
Cagle J, Harrington S, (1995) Insurance supply with capacity constraints and endogenous insolvency risk. J Risk Uncertainty 11:219–232
Cardon J, Hendel I, (2001) Asymmetric information in health insurance: evidence from the National Health Expenditure Survey. Rand J Econ 32:408–427
Cawley J, Philipson T, (1999) An empirical examination of information barriers to trade in insurance. Am Econ Rev 89:827–846
Chang PM, Peng J-L, Fan CK (2011) A comparison of bancassurance and traditional insurer sales channels. Gen Papers Risk Insur Issues Pract 36:76–93
Chang YM, Ehrlich I, (1985) Insurance, protection from risk and risk bearing. Can J Econ 18:574–587
Chen H, Cox S, (2009) Modeling mortality with jumps: applications to mortality securitization. J Risk Insur 76:727–751
Chen R, Wong KA, Lee HC (1999) Underwriting cycles in Asia. J Risk Insur 66:29–47
Cheng J, Elyasani E, Jia J (2011) Institutional ownership stability and risk-taking: evidence from the life-health insurance industry. J Risk Insur 78:609–641
Chesney M, Loubergé H (1986) Risk aversion and the composition of wealth in the demand for full insurance coverage. Schweizerische Zeitschrift für Volkswirt-schaft und Statistik 122:359–370
Chiappori P, Durand F, Geoffard PY (1998) Moral hazard and the demand for physician services: first lessons from a French natural experiment. Eur Econ Rev 42:499–511
Chiappori PA, Macho I, Rey P, Salanié B (1994) Repeated moral hazard: the role of memory, commitment and the access to credit markets. Eur Econ Rev 38:1527–1553
Chiappori P, Salanié B (2000) Testing for asymmetric information in insurance markets. J Polit Econ 108: 56–78
Choi S, Hardigree D, Thistle P (2002) The property-liability insurance cycle: acomparison of alternative models. South Econ J 68:530–548
Cohen A (2005) Asymmetric information and learning in the automobile insurance market. Rev Econ Stat 87:197–207
Cohen A, Dehejia R, (2004) The effects of automobile insurance and accident liabilities laws on traffic fatalities. J Law Econ 47:357–393
Cohen A, Siegelman P, (2010) Testing for adverse selection in insurance markets. J Risk Insur 77: 39–84
Cook PJ, Graham DA, (1977) The demand for insurance production: the case of irreplaceable commodities. Q J Econ 91:143–156
Cooper R, Hayes B, (1987) Multi-period insurance contracts. Int J Ind Organ 5:211–231
Courbage C, Rey B, (2006) Prudence and optimal prevention for health risks. Health Econ 15:1323–1327
Courbage C, Rey B, (2012) Optimal prevention and other risks in a two-period model. Math Soc Sci 63:213–217
Courbage C, Stahel W (eds) (2012) Extreme events and insurance: 2011 Annus Horribilis, Geneva Reports No 5, Geneva Association
Cowley A, Cummins JD, (2005) Securitization of life insurance assets and liabilities. J Risk Insur 72:193–226

Crocker KJ, Morgan J, (1998) Is honesty the best policy? Curtailing insurance fraud through optimal incentive contracts. J Polit Econ 106:355–375
Crocker KJ, Snow A, (1985) The efficiency of competitive equilibria in insurance markets with adverse selection. J Public Econ 26:207–219
Crocker KJ, Snow A, (1986) The efficiency effects of categorical discrimination in the insurance industry. J Polit Econ 94:321–344
Crocker KJ, Snow A, (2008) Background risk and the performance of insurance markets under adverse selection. Gen Risk Insur Rev 33:137–160
Croker KJ, Snow A, (2011) Multidimensional screening in insurance markets with adverse selection. J Risk Insur 78:287–307
Cummins JD (1988) Risk-based premiums for insurance guaranty funds. J Finan 43:823–839
Cummins JD (2005) Convergence in wholesale financial services: reinsurance and investment banking. Gen Papers Risk Insur Issues Pract 30:187–222
Cummins JD (2007) Reinsurance for natural and man-made catastrophes in the United States: current state of the market and regulatory reforms. Risk Manag Insur Rev 10:179–220
Cummins JD (2008) Cat bonds and other risk-linked securities: state of the market and recent developments. Risk Manag Insur Rev 11:23–47
Cummins JD (2012) Cat bonds and other risk-linked securities: product design and evolution of the market. In: Courbage C, Stahel R (ed) Chapter 4, Geneva Association, p 39–61
Cummins JD, Danzon P, (1997) Price, financial quality, and capital flows in insurance markets. J Finan Intermed 6:3–38
Cummins JD, Doherty N, (2002) Capitalization of the property-liability insurance industry: overview. J Finan Serv Res 21:5–14
Cummins JD, Doherty N, (2006) The economics of insurance intermediaries. J Risk Insur 73:359–396
Cummins JD, Doherty N, Lo A (2002) Can insurers pay for the 'big one'? Measuring the capacity of the insurance market to respond to catastrophic losses. J Banking Finan 26:557–583
Cummins JD, Geman H, (1995) Pricing catastrophe futures and call spreads. J Fixed Income 4: 46–57
Cummins JD, Harrington SE, (1985) Property-liability insurance rate regulation: estimation of underwriting betas using quarterly profit data. J Risk Insur 52:16–43
Cummins JD, Harrington SE, (1987) The impact of rate regulation on property-liability insurance loss ratios: a cross-sectional analysis with individual firm data. Gen Papers Risk Insurance 12:50–62
Cummins JD, Lalonde D, Phillips RD (2004) The basis risk of index-linked catastrophic loss securities. J Finan Econ 71:77–111
Cummins JD, Mahul O, (2003) Optimal insurance with divergent beliefs about insurer total default risk. J Risk Uncertainty 27:121–138
Cummins JD, Nini G, (2002) Optimal capital utilization by financial firms: evidence from the property-liability insurance industry. J Finan Serv Res 21:15–54
Cummins JD, Outreville JF, (1987) An international analysis of underwriting cycles in property-liability insurance. J Risk Insur 54:246–262
Cummins JD, Phillips R, Tennyson S (2001) Regulation, political influence and the price of automobile insurance. J Insur Regul 20:9–50
Cummins JD, VanDerhei JL, (1979) A note on the relative efficiency of property-liability insurance distribution systems. Bell J Econ 10:709–720
Cummins JD, Weiss M, (2009) Convergence of insurance and financial markets: hybrid and securitized risk-transfer solutions. J Risk Insur 76:493–545
Cummins JD, Weiss M, Zi H (1999) Organizational form and efficiency: the coexistence of stock and mutual property-liability insurers. Manag Sci 45:1254–1269
Cutler D, Reber S, (1998) Paying for health insurance: the trade-off between competition and adverse selection. Q J Econ 113:433–466
Dachraoui K, Dionne G, Eeckhoudt L, Godfroid P (2004) Comparative mixed risk aversion: definition and application to self-protection and willingness to pay. J Risk Uncertainty 29:261–276
Dahlby B (1983) Adverse selection and statistical discrimination: an analysis of Canadian automobile insurance market. J Public Econ 20:121–131
Dahlby B (1992) Testing for asymmetric information in Canadian automobile insurance. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 423–443
Danzon PM (1983) Rating bureaus in US property-liability insurance markets: anti or pro-competitive? Gen Papers Risk Insur 8:371–402
Danzon PM, Harrington S, (1992) The demand for and supply of liability insurance. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers
D'Arcy SP (1988) Application of economic theories of regulation to the property-liability insurance industry. J Insur Regul 7:19–52

D'Arcy SP, Doherty N, (1990) Adverse selection, private information and lowballing in insurance markets. J Bus 63:145–163
D'Arcy SP, France VG, (1992) Catastrophe futures: a better hedge for insurers. J Risk Insur 59:575–601
de Garidel-Thoron T (2005) Welfare-improving asymmetric information in dynamic insurance markets. J Polit Econ 113:121–150
De Meza D, Webb D, (2001) Advantageous selection in insurance markets. Rand J Econ 32:249–262
Derrig R (2002) Insurance fraud. J Risk Insur 69:271–287
Dickinson GM (1977) International insurance transactions and the balance of payments. Gen Papers Risk Insur No 6:17–35
Dionne G (1982) Moral hazard and state-dependent utility function. J Risk Insur 49:405–423
Dionne G (1983) Adverse selection and repeated insurance contracts. Gen Papers Risk Insur 8:316–333
Dionne G (1984) Search and insurance. Int Econ Rev 25:357–367
Dionne G, Doherty N, (1992) Adverse selection in insurance markets: a selective survey. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 97–140
Dionne G, Doherty N, (1994) Adverse selection, commitment and renegociation: extension to and evidence from insurance markets. J Polit Econ 102:209–235
Dionne G, Eeckhoudt L, (1984) Insurance and saving: some further results. Insur Math Econ 3:101–110
Dionne G, Eeckhoudt L, (1985) Self insurance, self protection and increased risk aversion. Econ Lett 17:39–42
Dionne G, Eeckhoudt L, (1988) Increasing risk and self-protection activities. Gen Papers Risk Insur 13
Dionne G, Giuliano F, Picard P (2009) Optimal auditing with scoring: theory and application to insurance fraud. Manag Sci 55:58–70
Dionne G, Gollier C, (1992) Comparative statics under multiple sources of risk with applications to insurance demand. Gen Papers Risk Insur Theory 17:21–33
Dionne G, Gourieroux C, Vanasse C (2001) Testing for evidence of adverse selection in the automobile insurance market: a comment. J Polit Econ 109:444–453
Dionne G, Harrington SE, (1992) An introduction to insurance economics. In: Dionne G, Harrington SE (eds) Foundations of insurance economics.). Kluwer Academic Publishers, p 1–48
Dionne G, Lasserre P, (1985) Adverse selection, repeated insurance contracts and announcement strategy. Rev Econ Stud 52:719–723
Dionne G, Lasserre P, (1987) Dealing with moral hazard and adverse selection simulataneously working paper. University of Pennsylvania
Dionne G, Li J, (2011) The impact of prudence on optimal prevention revisited. Econ Lett 113:147–149
Dionne G, Michaud PC, Dahchour M (2013) Separating moral hazard from adverse selection and learning in automobile insurance: longitudinal evidence from France. J Eur Econ Assoc, forthcoming
Dionne G, Pinquet J, Maurice M, Vanasse C (2011) Incentive mechanisms for safe driving: a comparative analysis with dynamic data. Rev Econ Stat 93:218–227
Dionne G, St-Michel P (1991) Workers' compensation and moral hazard. Rev Econ Stat 73:236–244
Doherty N (1981) The measurement of output and economies of scale in property-liability insurance. J Risk Insur 48:390–402
Doherty N (1984) Portfolio efficient insurance buying strategies. J Risk Insur 51:205–224
Doherty N (1997) Corporate insurance: competition from capital markets and financial institutions. Assurances 65:63–94
Doherty N, Dionne G, (1993) Insurance with undiversifiable risk: contract structure and organizational form of insurance firms. J Risk Uncertainty 6:187–203
Doherty N, Eeckhoudt L, (1995) Optimal insurance without expected utility: the dual theory and the linearity of insurance contracts. J Risk Uncertainty 10:157–179
Doherty N, Garven JR, (1995) Insurance cycles: interest rates and the capacity constraint model. J Bus 68:383–404
Doherty N, Garven JR, (1986) Price regulation in property-liability insurance: a contingent claims approach. J Finan 41:1031–1050
Doherty N, Jung HJ, (1993) Adverse selection when loss severities differ: first-best and costly equilibria. Gen Papers Risk Insur Theory 18:173–182
Doherty N, Kang HB, (1988) Price instability for a financial intermediary: interest rates and insurance price cycle. J Bank Finan 12:191–214
Doherty N, Loubergé H, Schlesinger H (1987) Risk premiums with multiple sources of risk. Scand Actuar J 41–49
Doherty N, Phillips R, (2002) Keeping up with the Joneses: changing rating standards and the buildup of capital by U.S. property-liability insurers. J Finan Serv Res 21:55–78
Doherty N, Posey L, (1998) On the value of a checkup: adverse selection, moral hazard and the value of information. J Risk Insur 65:189–211
Doherty N, Richter A, (2002) Moral harard, basis risk and gap insurance. J Risk Insur 69:9–24
Doherty N, Schlesinger H (1983a) Optimal insurance in incomplete markets. J Polit Econ 91:1045–1054

Doherty N, Schlesinger H (1983b) The optimal deductible for an insurance policy when initial wealth is random. J Bus 56:555–565
Doherty N, Schlesinger H, (1990) Rational insurance purchasing: considerations of contract non-performance. Q J Econ 105:243–253
Doherty N, Schlesinger H, (1995) Severity risk and the adverse selection of frequency risk. J Risk Insur 62:649–665
Doherty N, Schlesinger H, (2002) Insurance contracts and securitization. J Risk Insur 69:45–62
Doherty N, Thistle P, (1996) Adverse selection with endogenous information in insurance markets. J Public Econ 63:83–102
Doherty N, Tinic S, (1981) "Reinsurance under conditions of capital market equilibrium" J Finan 36:949–953
Drèze J (1979) Human capital and risk-bearing. Gen Papers Risk Insur No 12:5–22
Drèze J (1990) The role of securities and labor contracts in the optimal allocation of risk-bearing. In: Loubergé H (ed) Risk, information and insurance. Kluwer Academic Publishers, p 41–65
Eckart M, Räthke-Döppner S (2010) The quality of insurance intermediaries services—empirical evidence for Germany. J Risk Insur 77:667–701
Eeckhoudt L, Gollier C, (2005) The impact of prudence on optimal prevention. Econ Theory 26:989–994
Eeckhoudt L, Gollier C, Schlesinger H (1991) Increases in risk and deductible insurance. J Econ Theory 55: 435–440
Eeckhoudt L, Gollier C, Schlesinger H (1996) Changes in background risk and risk-taking behavior. Econometrica 64:683–689
Eeckhoudt L, Kimball M, (1992) Background risk, prudence, and the demand for insurance. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 239–254
Eeckhoudt L, Meyer J, Ormiston MB (1997) The interactions between the demand for insurance and insurable assets. J Risk Uncertainty 14:25–39
Eeckhoudt L, Rey B, Schlesinger H (2007) A good sign for multivariate risk taking. Manag Sci 53:117–124
Einav L, Finkelstein A, Cullen M (2010) Estimating welfare in insurance markets using variations in prices. Q J Econ 125:877–921
Einav L, Finkelstein A, (2011) Selection in insurance markets: theory and empirics in pictures. J Econ Perspect 25:115–138
Eisen R (1990) Problems of equilibria in insurance markets with asymmetric informa-tion. In: Loubergé H (ed) Risk, information and insurance. Kluwer Academic Publishers, p 123–141
Ekern S, Persson SA, (1996) Exotic unit-linked life insurance contracts. In Loubergé H, Subrahmanyam M (eds) Financial risk and derivatives. Kluwer Academic Publishers, p 35–63
Eling M, Schmeiser H, (2010) Insurance and the credit crisis: impact and ten consequences for risk management and supervision. Gen Papers Risk Insur Theory Pract 35:9–34
Eling M, Schmeiser H, Schmit J (2007) The Solvency II process: overview and critical analysis. Risk Manag Insur Rev 10:69–85
Fagart MC, Picard P, (1999) Optimal insurance under random auditing. Gen Papers Risk Insur Theory 24:29–54
Fang H, Keane M, Silverman D (2008) Sources of advantageous selection: evidence from the medigap insurance market. J Polit Econ 116:303–350
Fairley W (1979) Investment income and profit margins in property-liability insurance: theory and empirical results. Bell J Econ 10:192–210
Fecher F, Perelman S, Pestieau P (1991) "Scale economies and performance in the French insurance industry," Gen Papers Risk Insur Issues Pract No 60:315–326
Finkelstein A, McGarry K, (2006) Multiple dimensions of private information: evidence from the long-term care insurance market. Am Econ Rev 96:938–958
Finkelstein A, Poterba J, (2002) Selection effects in the United Kingdom individual annuities market. Econ J 112:28–50
Finkelstein A, Poterba J, (2004) Adverse selection in insurance markets: policyholder evidence from the U.K. annuity market. J Polit Econ 112:183–2008
Finken S, Laux C, (2009) Catastrophe bonds and reinsurance: the competitive effect of information-sensitive triggers. J Risk Insur 76:579–605
Finsinger J, Pauly M, (1984) Reserve levels and reserve requirements for profi-maximizing insurance firms. In: Bamberg G, Spremann K (eds) Risk and capital. Springer Verlag, p 160–180
Fluet C, Pannequin F, (1997) Complete versus incomplete insurance contracts under adverse selection with multiple risks. Gen Papers Risk Insur Theory 22:81–101
Froot K (1999) The evolving market for catastrophic event risk. Risk Manag Insur Rev 2:1–28
Froot K (ed.) (1999) The financing of catastrophe risk University of Chicago Press.
Froot K (2001) The market for catastrophic risk: a clinical examination. J Finan Econ 60:529–571
Froot K, O'Connell P (2008) On the pricing of intermediated risks: theory and application to catastrophe reinsurance. J Bank Finan 32:69–85
Froot K, Sharfstein D, Stein J (1993) Risk management: coordinating corporate investment and financial policies. J Finan 48:1629–1658

Fudenberg D, Tirole J, (1990) Moral hazard and renegociation in agency contracts. Econometrica 58:1279–1319
Garven JR (1987) On the application of finance theory to the insurance firm. J Finan Serv Res 1:57–76
Garven JR, Lamm-Tenant J (2003) The demand for reinsurance: theory and tests. Insur Risk Manag 71:217–238
Garven JR, Loubergé H (1996) Reinsurance, taxes and efficiency: a contingent claims model of insurance market equilibrium. J Finan Intermed 5:74–93
Geneva Association (2010) Systemic risk in insurance—an analysis of insurance and financial stability. Geneva Association, Geneva
Gollier C (1992) Economic theory of risk exchanges: a review. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 3–23
Gollier C (1995) The comparative statics of changes in risk revisited. J Econ Theory 66:522–536
Gollier C (2003) To insure or not to insure? An insurance puzzle. Gen Papers Risk Insur Theory 28:5–24
Gollier C, Pratt JW, (1996) Risk vulnerability and the tempering effect of background risk. Econometrica 64:1109–1123
Gollier C, Scarmure P, (1994) The spillover effect of compulsory insurance. Gen Papers Risk Insur Theory 19:23–34
Gollier C, Schlee E, (1997) "Increased risk taking with multiple risks," working paper
Gollier C, Schlesinger H, (1995) Second best insurance contract design in an incomplete market. Scand J Econ 97:123–135
Gollier C, Schlesinger H, (1996) Arrow's theorem on the optimality of deductibles: a stochastic dominance approach. Econ Theory 7:359–363
Grace MF, Hotchkiss JL, (1995) External impacts on the property-liability insurance cycle. J Risk Insur 62: 738–754
Gron A (1994) Evidence of capacity constraints in insurance markets. J Law Econ 37:349–377
Grossman S, Hart OD, (1983) An analysis of the principal-agent problem. Econometrica 51:7–45
Guiso L, Jappelli T, (1998) Background uncertainty and the demand for insurance against insurable risks. Gen Papers Risk Insur Theory 23:7–27
Haley J (1993) A cointegration analysis of the relationship between underwriting margins and interest rates: 1930–1989. J Risk Insur 60:480–493
Hansmann H (1985) The organization of insurance companies: mutual versus stock. J Law Econ Organ 1: 125–153
Harrington SE (1984) The impact of rate regulation on prices and underwriting results in the property-liability insurance industry: a survey. J Risk Insur 51: 577–617
Harrington SE (1987) A note on the impact of auto insurance rate regulation. Rev Econ Stat 69:166–170
Harrington SE (1988) Prices and profits in the liability insurance market. In: Litan R, Winston C (eds) Liability: perspectives and policy. The Brooking Institution, p 42–100
Harrington SE (2009) The financial crisis, systemic risk, and the future of insurance regulation. J Risk Insur 76:785–819
Harrington SE, Danzon P, (1994) Price-cutting in liability insurance markets. J Bus 67:511–538
Harrington S, Niehaus G, (1999) Basis risk with PCS catastrophe insurance derivative contracts. J Risk Insur 66:49–82
Harrington S, Niehaus G, (2002) Capital structure decisions in the insurance industry: stocks versus mutuals. J Finan Serv Res 21:145
He E, Sommer D, (2011) CEO turnover and ownership structure: evidence from the US property-liability insurance industry. J Risk Insur 78:673–701
Hellwig M (1988) A note on the specification of interfirm communication in insurance markets with adverse selection. J Econ Theory 46:154–163
Helpman E, Laffont JJ, (1975) On moral hazard in general equilibrium. J Econ Theory 10:8–23
Hemenway D (1990) Propitious selection. Q J Econ 105:1063–1069
Hendel I, Lizzeri A, (2003) The role of commitment in dynamic contracts: evidence from life insurance. Q J Econ 118:299–327
Hill RD (1979) Profit regulation in property-liability insurance. Bell J Econ 10:172–191
Hill RD, Modigliani F, (1986) The Massachussets model of profit regulation in nonlife insurance: theory and empirical results. In: Cummins JD, Harrington SE (eds) Fair rate of return in property-liability insurance. Kluwer Academic Publishers
Hong SK, Lew KO, MacMinn R, Brockett P (2011) Mossin's theorem given random initial wealth. J Risk Insur 78:309–324
Holmstrom B (1979) Moral hazard and observability. Bell J Econ 10:74–91
Hosios AJ, Peters M, (1989) Repeated insurance contracts with adverse selection and limited commitment. Q J Econ 104:229–253
Hoy M (1982) Categorizing risks in the insurance industry. Q J Econ 97:321–336
Hoy M, Robson RJ, (1981) Insurance as a giffen good. Econ Lett 8:47–51
Hoyt R, Liebenberg A, (2011) The value of enterprise risk management. J Risk Insur 78:795–822
Hoyt R, Mustard D, Powell L (2006) The effectiveness of state legislation mitigating moral hazard: evidence from automobile insurance. J Law Econ 49:427–450
Huang L-Y, Lai G, McNamara M, Wang J (2011) Corporate governance and efficiency: evidence from US property-liability insurance industry. J Risk Insur 78:519–550

Huberman G, Mayers D, Smith CW (1983) Optimal insurance policy indemnity schedules. Bell J Econ 14: 415–426
Ippolito R (1979) The effects of price regulation in the automobile insurance industry. J Law Econ 22: 55–89
Jang Y, Hadar J, (1995) A note on increased probability of loss and the demand for insurance. Gen Papers Risk Insur Theory 20:213–216
Jean-Baptiste E, Santomero A, (2000) The design of private reinsurance contracts. J Finan Intermed 9: 274–297
Jullien B, Salanié B, Salanié F (1999) Should more risk averse agents exert more effort? Gen Papers Risk Insur Theory 24:19–28
Kahane Y (1977) Capital adequacy and the regulation of financial intermediaries. J Bank Finan 1:207–218
Kahane Y, Kroll Y, (1985) Optimal insurance coverage in situations of pure and speculative risk and the risk-free asset. Insur Math Econ 4:191–199
Kahane Y, Nye DJ, (1975) A portfolio approach to the property-liability insurance industry. J Risk Insur 42:579–598
Karni E (1992) Optimal insurance: a nonexpected utility analysis. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 217–238
Karni E (1995) Non-expected utility and the robustness of the classical insurance paradigm—discussion. In: Gollier C, Machina M (eds) Non-expected utility and risk management. Kluwer Academic Publishers, p 51–56
Kielholz W, Durrer A, (1997) Insurance derivatives and securitization: new hedging perspectives for the US cat insurance market. Gen Papers Risk Insur Issues Pract, No 82:3–16
Kihlstrom RE, Romer D, Williams S (1981) Risk aversion with random initial wealth. Econometrica 49:911–920
Kimball M (1990) Precautionary saving in the small and in the large. Econometrica 58:53–73
Klein R (2012) Principles for insurance regulation: an evaluation of current practices and potential reforms. Gen Papers Risk Insur Issues Pract 37:175–199
Klein R, Phillips R, Shiu W (2002) The capital structure of firms subject to price regulation: evidence from the insurance industry. J Finan Serv Res 21:79–100
Klein R, Wang S, (2009) Catastrophe risk financing in the United States and the European Union: a comparative analysis of alternative regulatory approaches. J Risk Insur 76:607–637
Klick J, Stratmann T, (2007) Diabetes treatment and moral hazard. J Law Econ 50:519–538
Konrad K, Skaperdas S, (1993) Self-insurance and self-protection: a non-expected utility analysis. Gen Papers Risk Insur Theory 18
Kraus A, Ross SA, (1982) The determinants of fair profits for the property-liability insurance firm. J Finan 37:1015–1030
Kunreuther H (1996) Mitigating disaster losses through insurance. J Risk Uncertainty 12:171–187
Kunreuther H, Michel-Kerjan E (2009) At war with the weather. MIT Press, Cambridge
Kunreuther H, Pauly M, (1985) Market equilibrium with private knowledge: an insurance example. J Public Econ 26:269–288
Kunreuther H, Pauly M, (2004) Neglecting disaster: why don't people insure against large losses? J Risk Uncertainty 28:5–21
Kunreuther H, Pauly M, (2005) Insurance decision-makink and market behavior. Found Trends Microecon 1:63–127
Kunreuther H, Pauly M, (2006) Rules rather than discretion: lessons from Hurricane Katrina. J Risk Uncertainty 33:101–116
Lambert R (1983) Long-term contracts and moral hazard. Bell J Econ 14:441–452
Lamm-Tennant J, Weiss M, (1997) International insurance cycles: rational expectations/institutional intervention. J Risk Insur 64:415–439
Landsberger M, Meilijson I, (1996) Extraction of surplus under adverse selection: the case of insurance markets. J Econ Theory 69:234–239
Lee JP, Yu MT, (2002) Pricing default-risky cat bonds with moral hazard and basis risk. J Risk Insur 69: 25–44
Lee K (2005) Wealth effects on self-insurance and self-protection against monetary and nonmonetary losses. Gen Risk Insur Rev 30:147–159
Lee K (2010) Wealth effects on self-insurance. Gen Risk Insur Rev 35:160–171
Lee K (2012) Background risk and self-protection. Econ Lett 114:262–264
Lehmann A, Hofmann D, (2010) Lessons learned from the financial crisis for risk management: contrasting developments in insurance and banking. Gen Papers Risk Insur Issues Pract 35:63–78.
Lemaire J (1990) Borch's theorem: a historical survey of applications. In: Loubergé H (ed) Risk, information and insurance. Kluwer Academic Publishers, p 15–37
Leng CC, Meier U, (2006) Analysis of multinational underwriting cycles in property-liability insurance. J Risk Finan 7:146–159
Lewis CM, Murdock KC, (1996) The role of government contracts in discretionary reinsurance markets for natural disasters. J Risk Insur 63:567–597
Li J (2011) The demand for a risky asset in the presence of a background risk. J Econ Theory 146:372–391
Lin J, Cox S, (2005) Securitization of mortality risks in life annuities. J Risk Insur 72:227–252

Litzenberger R, Beaglehole D, Reynold C (1996) Assessing catastrophe reinsurance-linked securities as a new asset class. J Portfolio Manag 23:76–86
Loubergé H (1983) A portfolio model of international reinsurance operations. J Risk Insur 50:44–60
Loubergé H, Kellezi E, Gilli M (1999) Using catastrophe-linked securities to diversify insurance risk: a financial analysis of cat bonds. J Insur Issues 22:125–146
Loubergé H, Watt R (2008) Insuring a risky investment project. Insur Math Econ 42:301–310
Machina M (1982) Expected utility analysis without the independence axiom. Econometrica 50:277–323
Machina M (1995) Non-expected utility and the robustness of the classical insurance paradigm. In: Gollier C, Machina M (eds) Non-expected utility and risk management. Kluwer Academic Publishers, p 9–50
MacMinn RD, Witt RC, (1987) A financial theory of the insurance firm under uncertainty and regulatory constraints. Gen Papers Risk Insur 12:3–20
Magnan S (1995) Catastrophe insurance system in France. Gen Papers Risk Insur No 77:474–480
Mahul O (2000) Optimal insurance design with random initial wealth. Econ Lett 69:353–358
Main B (1982) Business insurance and large, widely-held corporations. Gen Papers Risk Insur 7:237–247
Makki S, Somwaru A, (2001) Evidence of adverse selection in crop insurance markets. J Risk Insur 68:685–708
Marshall JM (1974) Insurance theory: reserves versus mutuality. Econ Inquiry 12:476–492
Marshall JM (1976) Moral hazard. Am Econ Rev 66:880–890
Mayers D, Smith CW, (1981) Contractual provisions, organizational structure, and conflict control in insurance markets. J Bus 54:407–434
Mayers D, Smith CW, (1982) On the corporate demand for insurance. J Bus 55:281–296
Mayers D, Smith CW, (1983) The interdependence of individual portfolio decisions and the demand for insurance. J Polit Econ 91:304–311
Mayers D, Smith CW, (1986) Ownership structure and control: the mutualization of stock life insurance companies. J Finan Econ 16:73–98
Mayers D, Smith CW, (1988) Ownership structure across lines of property-casualty insurance. J Law Econ 31:351–378
Mayers D, Smith CW, (1990) On the corporate demand for insurance: evidence from the reinsurance market. J Bus 63:19–40
Mayers D, Smith CW, (2002) Ownership structure and control: property-casualty insurer conversion to stock charter. J Finan Serv Res 21:117–144
Meier U, Outreville JF, (2006) Business cycles in insurance and reinsurance: the case of France, Germany and Switzerland. J Risk Finan 7:160–176
Meyer J (1992) Beneficial changes in random variables under multiple sources of risk and their comparative statics. Gen Papers Risk Insur Theory 17:7–19
Meyer D, Meyer J (1998a) Changes in background risk and the demand for insurance. Gen Papers Risk Insur Theory 23:29–40
Meyer D, Meyer J (1998b) The comparative statics of deductible insurance and insurable assets. J Risk Insur 66:1–14
Meyer D, Meyer J, (2004) A more reasonable model of insurance demand. In: Aliprantis CD et al. (eds.) Assets, beliefs and equilibria in economic dynamics—essays in honor of Mordecai Kurz. Springer, p 733–742
Meyer J, Ormiston MB, (1995) Demand for insurance in a portfolio setting. Gen Papers Risk Insur Theory 20:203–212
Meulbroek L (2002) Integrated risk management for the firm: a senior manager's guide. J Appl Corpor Finan 14: 56–70
Michel-Kerjan E, Morlaye F (2008) Extreme events, global warming, and insurance-linked securities: how to trigger the 'Tipping point'. Gen Papers Risk Insur Issues Pract 33:153–176
Miyazaki H (1977) The rat race and internal labor markets. Bell J Econ 8:394–418
Moffet D (1977) Optimal deductible and consumption theory. J Risk Insur 44:669–683
Moffet D (1979) The risk-sharing problem. Gen Papers Risk Insur 4:5–13
Monti A (2011) "Public-private initiative to cover extreme events" Chapter 3. Courbage and Stahel 27–38
Mookherjee D, Png I, (1989) Optimal auditing, insurance and redistribution. Q J Econ 104:205–228
Mormino CA (1979) "Insurance cycles: an Italian experience". Etudes et Dossiers de l'Association de Genève No 33.
Munch P, Smallwood DE, (1980) Solvency regulation in the property-liability insurance industry: empirical evidence. Bell J Econ 11:261–282
Myers SC, Cohn RA, (1986) A discounted cash flow approach to property-liability insurance rate regulation. In: Cummins JD, Harrington SE (eds) Fair rate of return in property-liability insurance. Kluwer Academic Publishers
Nell M, Richter A, (2004) Improving risk allocation through indexed cat bonds Gen Papers Risk Insur Issues Pract 29:183–201
Nielsen JA, Sandmann K, (1996) Uniqueness of the fair premium for equity-linked life insurance contracts In: Loubergé H, Subrahmanyam M (eds) Financial risk and derivatives. Kluwer Academic Publishers, p 65–102
OECD (2005) Catastrophic risk and insurance. OECD, Paris
Pauly M (1974) Overinsurance and public provision of insurance: the role of moral ha-zard and adverse selection Q J Econ 88:44–62

Pauly M, Kleindorfer PR, Kunreuther H (1986) Regulation and quality competition in the US insurance industry. In: Finsinger J, Pauly M (eds) The economics of insurance regulation. MacMillan
Picard P (1996) Auditing claims in insurance markets with fraud: the credibility issue J Public Econ 63:27–56
Pita Barros P (1993) Freedom of services and competition in insurance markets Gen Papers Risk Insur Theory 18.
Plantin G (2006) Does reinsurance need reinsurers? J Risk Insur 73:153–168
Polemarchakis H (1990) Competitive allocation when the asset market is incomplete Gen Papers Risk Insur Theory 15.
Powell LS, Sommer DW, (2007) Internal versus external markets in the insurance industry: the role of reinsurance J Finan Serv Res 31:173–188
Priest GL (1996) The government, the market and the problem of catastrophic losses J Risk Uncertainty 12:219–237
Puelz R, Snow A, (1994) Evidence on adverse selection: equilibrium signalling and cross-subsidization in the insurance market J Polit Econ 102:236–257
Quiggin JC (1982) A theory of anticipated utility J Econ Behav Organ 3:323–343
Radner R (1981) Monitoring cooperative agreements in a repeated principal-agent relationship Econometrica 49:1127–1148
Raviv A (1979) The design of an optimal insurance policy Am Econ Rev 69:84–86
Razin A (1976) Rational insurance purchasing J Finan 31:133–137
Rea SA (1992) Insurance classifications and social welfare. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 377–396
Rees R, Gravelle H, Wambach A (1999) Regulation of insurance markets Gen Papers Risk Insur Theory 24: 55–68
Rey B (2003) A note on optimal insurance in the presence of a nonpecuniary background risk Theory Decis 54:73–83
Richaudeau D (1999) Automobile insurance contracts and risk of accident: an empirical test using French individual data Gen Papers Risk Insur Theory 24: 97–114
Riley JG (1979) Informational equilibrium Econometrica 47:331–359
Robinson C, Zheng B, (2010) Moral hazard, insurance claims and repeated insurance contracts Can J Econ 43:967–993
Rochet JC, Villeneuve S, (2011) Liquidity management and corporate demand for hedging and insurance J Finan Intermed 20:303–323
Ross S (1981) Some stronger measures of risk aversion in the small and in the large with applications Econometrica 49:621–638
Rothschild C (2011) The efficiency of categorical discrimination in insurance markets J Risk Insur 78:267–285
Rothschild M, Stiglitz JE, (1970) Increasing risk: I—a definition J Econ Theory 2:225–243
Rothschild M, Stiglitz JE, (1976) Equilibrium in competitive insurance markets: the economics of markets with imperfect information Q J Econ 90:629–650
Rothschild M, Stiglitz JE, (1997) Competition and insurance twenty years later Gen Papers Risk Insur Theory 22: 73–79
Rowell D, Connelly L, (2012) A history of the term 'moral hazard' J Risk Insur 79:1051–1076
Rubinstein A, Yaari ME, (1983) Repeated insurance contracts and moral hazard J Econ Theory 30: 74–97
Saito K (2006) Testing for asymmetric information in the automobile insurance market under rate regulation J Risk Insur 73:335–356
Sandroni A, Squintani F, (2007) Overconfidence, insurance and paternalism Am Econ Rev 97:1994–2004
Schlee E (1995) The comparative statics of deductible insurance in expected- and non-expected utility theories. In: Gollier C, Machina M (ed) Non-expected utility and risk management. Kluwer Academic Publishers, p 57–72
Schlesinger H (1984) Optimal insurance for irreplaceable commodities J Risk Insur 51:131–137
Schlesinger H (1997) Insurance demand without the expected utility paradigm J Risk Insur 64:19–39
Schlesinger H (1999) Decomposing catastrophic risk Insur Math Econ 24:95–101
Schlesinger H, Doherty N, (1985) Incomplete markets for insurance: an over-view J Risk Insur 52:402–423
von Schulenburg M (1986) Optimal insurance purchasing in the presence of compulsory insurance and insurable risks Gen Papers Risk Insur 38:5–16.
Segal U, Spivak A, (1990) First order versus second order risk aversion J Econ Theory 51:111–125
Shavell S (1979) On moral hazard and insurance Q J Econ 93:541–562
Shavell S (1982) On liability and insurance Bell J Econ 13:120–132
Shavell S (1986) The judgment proof problem Int Rev Law Econ 6:45–58
Shavell S (2000) On the social function and the regulation of liability insurance Gen Papers Risk Insur Issues Pract 25:166–179
Shim J (2011) Mergers & acquisitions, diversification and performance in the U.S. property-liability insurance industry J Finan Serv Res 39:119–144
Shiu YM (2011) Reinsurance and capital structure: evidence from the United Kingdom non-life insurance industry J Risk Insur 78:475–494
Sinn HW (1982) Kinked utility and the demand for human wealth and liability insurance Eur Econ Rev 17: 149–162
Smart M (2000) Competitive insurance markets with two unobservables Int Econ Rev 41:153–169
Smith C, Smithson C, Wilford S (1990) Financial engineering: why hedge? In: Handbook of financial engineering. Harper & Row, Chapter 5, p 126–137

Smith C, Stulz R, (1985) The determinants of firms' hedging policies J Finan Quant Anal 20:391–405
Spence M (1978) Product differentiation and performance in insurance markets J Pub Econ 10:427–447
Stiglitz JE (1977) Monopoly, non-linear pricing and imperfect information: the insurance market Rev Econ Stud 44:407–430
Stiglitz JE (1983) Risk, incentives and insurance: the pure theory of moral hazard Gen Papers Risk Insur 8:4–33
Stiglitz JE, Weiss A, (1981) Credit rationing in markets with imperfect information Am Econ Rev 71:393–410
Stulz R (1984) Optimal hedging policies J Finan Quant Anal 19:127–140
Sweeney GH, Beard R, (1992) The comparative statics of self-protection J Risk Insur 59:301–309
SwissRe (2009) The role of indices in transferring insurance risks to capital markets. Sigma, No 4
Tibiletti L (1995) Beneficial changes in random variables via copulas: an application to insurance Gen Papers Risk Insur Theory 20:191–202
Townsend R (1979) Optimal contracts and competitive contracts with costly state verification J Econ Theory 22:265–293
Tsetlin I, Winkler RL, (2005) Risky choices and correlated background risk Manag Sci 51:1336–1345
Turnbull S (1983) Additional aspects of rational insurance purchasing J Bus 56:217–229
Venezian E (1985) Ratemaking methods and profit cycles in property and liability insurance J Risk Insur 52: 477–500
Viscusi WK (1995) Insurance and Catastrophes: the changing role of the liability system Gen Papers Risk Insur Theory 20:177–184
Weiss M (2007) Underwriting cycles: a synthesis and further directions J Insur Issues 30:31–45
Wharton Risk Management Center (2007) Managing large-scale risks in a new era of catastrophe. Wharton School, Philadelphia
Wilson C (1977) A model of insurance markets with incomplete information J Econ Theory 12:167–207
Winter RA (1992) Moral hazard and insurance contracts. In: Dionne G (ed) Contributions to insurance economics. Kluwer Academic Publishers, p 61–96
Winter RA (1994) The dynamics of competitive insurance markets J Finan Intermed 3:379–415
Yaari M (1987) The dual theory of choice under risk Econometrica 55: 95–115
Young VR, Browne MJ, (1997) Explaining insurance policy provisions via adverse selection Gen Papers Risk Insur Theory 22:121–134
Zanjani G (2002) Pricing and capital allocation in catastrophe insurance J Finan Econ 65: 283–305
Zeckhauser R (1995) Insurance and catastrophes Gen Papers Risk Insur Theory 20: 157–175
Zou H, Adams M, (2008) Debt capacity, cost of debt, and corporate insurance J Finan Quant Anal 43:433–466
Zweifel P, Ghermi P, (1990) Exclusive vs. independent agencies: a comparison of performance Gen Papers Risk Insur Theory 15:171–192